



**TECHNICAL REPORT
NATICK/TR-01/016**

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**COMPARISON OF THE CENTRALIZED HEATING UNIT
COGENERATION KITCHEN (CHUCK WAGON) PROTOTYPE
WITH THE MOBILE KITCHEN TRAILER (MKT)
AND MOBILE KITCHEN TRAILER-IMPROVED (MKT-I)**

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Final Report
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14. ABSTRACT Tests were conducted at the U.S. Army's Natick Soldier Center (NSC) to evaluate the promise of a new piece of field feeding equipment, the Centralized Heating Unit Cogeneration Kitchen (CHUCK Wagon). Testing consisted of preparing and serving meals for 250 consumers on three separate days. The first two days, meals were prepared with a standard Mobile Kitchen Trailer (MKT) and an MKT-Improved (MKT-I) to establish a baseline against which the new kitchen could be compared. This demonstration proved the CHUCK Wagon can be used to prepare a quality meal for 250 troops. Most performance variables were found to be equal to or better than either MKT scenario. The CHUCK Wagon demonstrated an ability to perform many tasks in a substantially shorter time, and further showed superior efficiency using either diesel or JP-8 fuels for heat. The CHUCK Wagon remains developmental equipment and is constantly undergoing testing designed to improve its capabilities.					
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Preface

This report details results of a technical demonstration performed under the auspices of a Natick Soldier Center Combat Feeding Program Science and Technology Objective. This particular long-term endeavor supports development of equipment to provide Rapid Deployment Food Service for Force Projection.

Changes to field-feeding equipment were prompted by doctrine calling for the elimination of gasoline from military operations. A first step was to convert the M2 gasoline burner (used in kitchen appliances) to diesel fuel. Accordingly, the Modern Burner Unit was developed. Under the tech base came an opportunity for more revolutionary change. With the advent of thermal fluid technology, a single diesel or JP8-fired boiler could be used to heat food-grade mineral-oil circulated through appliances, and a whole new kitchen concept was born. The new target became a more efficient, easier to use kitchen that had commercial grade appliances integrated into a lighter, smaller platform. Prototypes demonstrating this ability were built, and it was realized that even higher efficiencies could be reached if cogeneration tactics were applied on a systemic basis.

The Centralized Heating Unit Cogeneration Kitchen (CHUCK Wagon) represents a culmination of what has been learned so far and is the first kitchen ever to utilize cogeneration. During a technical demonstration that spanned from October 1999 to January 2000, the CHUCK Wagon, the current Mobile Kitchen Trailer (MKT), and the MKT-Improved (MKT-I), were evaluated in side-by-side preparation of meals for 250 troops. Data for factors of technical and Manpower and Personnel Integration Team (MANPRINT) performance were gathered and are presented in this report.

Acknowledgements

This work was made possible through assistance from personnel at the Natick Soldier Center (NSC). In particular, special thanks goes to Frank DiLeo who developed the menu and procedures, organized personnel, procured the food used, helped with cooking, and arranged for any ancillary logistical matters. Thanks also to personnel from the Manpower and Personnel Integration Team (MANPRINT), Rose Guerra, Dawn Woods, and Marlene Devine; their input on human factors was essential to this evaluation. In addition, U.S. Army Specialist Dave Villar and Sergeant Lida Powell served as Food Operation Sergeants and offered valuable information on actual field-feeding operations. The authors also thank all other NSC personnel who acted as field cooks or worked in the sanitation facility.

Comparison of the Centralized Heating Unit Cogeneration Kitchen (CHUCK Wagon) with the Mobile Kitchen Trailer (MKT) and the MKT-Improved (MKT-I)

1. Summary

Tests were conducted at the U.S. Army's Natick Soldier Center to evaluate the promise of a new piece of field-feeding equipment, the Centralized Heating Unit Cogeneration Kitchen, a.k.a. The CHUCK Wagon (**Figure 1**). This kitchen is based on a previously demonstrated Modular Appliance Technology Centralized Heating (MATCH) system which uses one burner to heat a thermal fluid circulated to all appliances. The kitchen is built upon a High Mobility Trailer (HMT) and includes two kettles, a commercial convection oven, a griddle, hot and cold running water, and a generator for completely independent operation.

Because the Mobile Kitchen Trailer (MKT) is the most popular kitchen system in use today, its performance is the baseline against which all new concepts are measured. Testing therefore consisted of preparing and serving the Day 4, A-ration dinner for 250 consumers on 3 separate days, and each day a different kitchen was used. Besides the CHUCK Wagon, a standard Mobile Kitchen Trailer (MKT) with M2 burners, and a developmental MKT-Improved (MKT-I) using the Modern Burner Unit (MBU) were tested. The MKT is shown in **Figure 2**.

This demonstration proved the CHUCK Wagon can be used to adequately prepare quality A-ration meals for 250 troops. All foods turned out satisfactorily and with ease. Most performance variables were found to be equal to or better than either MKT scenario. Of particular interest was its ability to perform many tasks in a substantially shorter time. The setup time difference was the most significant, with the CHUCK Wagon taking only 13 minutes compared to about 90 minutes for the MKTs.

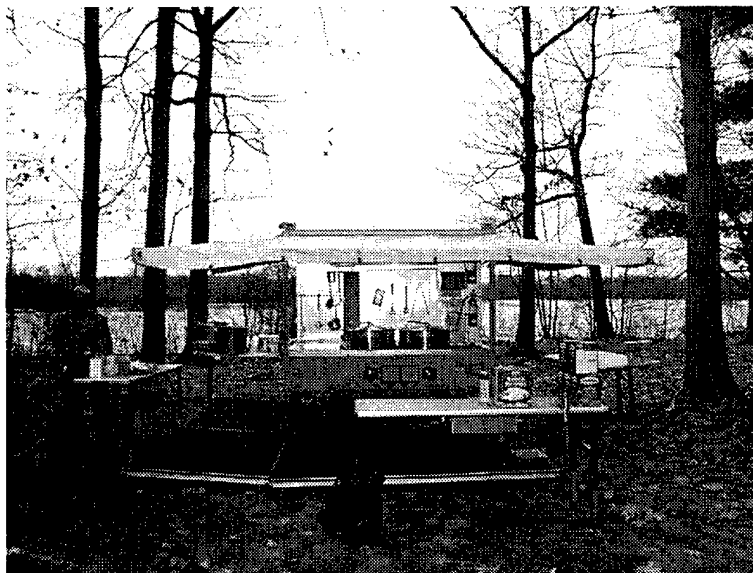


Figure 1. CHUCK Wagon

Another advantage of the CHUCK Wagon is that it can utilize diesel or JP8 fuel instead of gasoline as required of the MKT with M2 Burners. These heavier fuels are safer, more logistically supportable, and there is no need to handle fuel in preparing for operations. Of the three kitchens, the CHUCK Wagon used the least amount of fuel.

While there remain a variety of issues to be answered regarding the CHUCK system, it is still considered developmental equipment and is constantly being improved to resolve any matters this or subsequent testing will unearth.



Figure 2. Mobile Kitchen Trailer

2. Introduction

A variety of equipment exists for preparing hot, cooked meals in the field; of these, the basic MKT is the most commonly used kitchen system. It is mounted on an M-51 trailer, towable by 2 ½ ton vehicle and will feed 250 troops. It uses six M-2 burners (**Figure 3**) as heat sources for cooking appliances. An MKT-Improved (MKT-I) currently in development is, in most respects, identical to the MKT but includes several upgrades; most notably it uses six Modern Burner Units (MBUs) of the type shown in **Figure 4**, in place of the M2's.

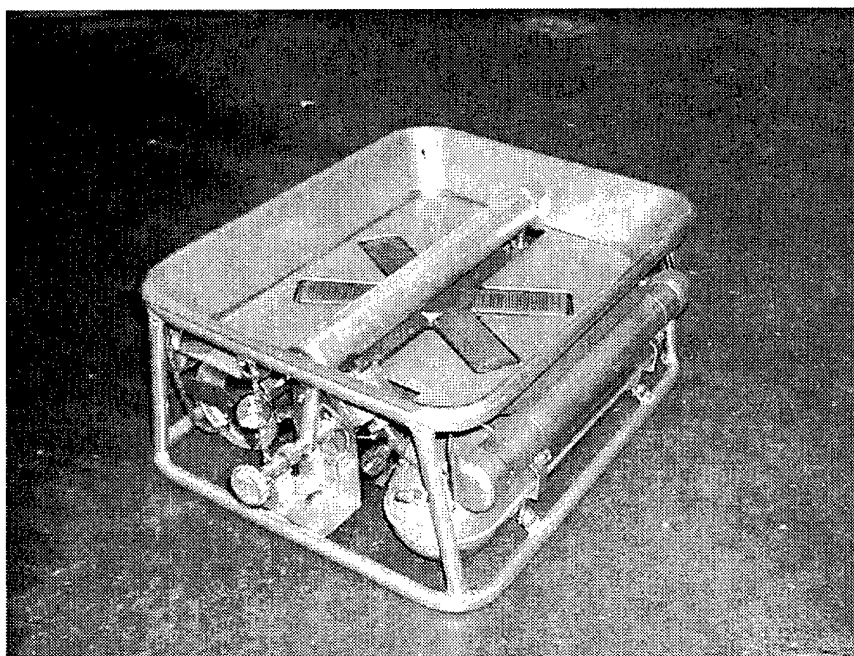


Figure 3. M2 Burner

Possibilities for improving field-feeding operations are routinely explored by Natick engineers. A newly developed kitchen trailer is the Centralized Heating Unit Cogeneration Kitchen (CHUCK Wagon). The CHUCK Wagon utilizes a new technology consisting of a single commercial oil burner heating a thermal fluid that is pumped out to appliances. All equipment is permanently mounted on a High Mobility Trailer (HMT) and towable by a High Mobility Multipurpose Wheeled Vehicle (HMMWV). This kitchen also is capable of feeding 250 troops.

Technical evaluations of each kitchen trailer were performed at the Natick Soldier Center during the fall and winter of 1999/2000. Efforts were made to collect similar data during each test, and comparisons of energy use, function, and human factor performance characteristics are presented in this report. Using the currently deployed MKT kit as a baseline, this exercise provided material to evaluate the technical merits and feasibility of the CHUCK Wagon to adequately prepare and serve hot meals.

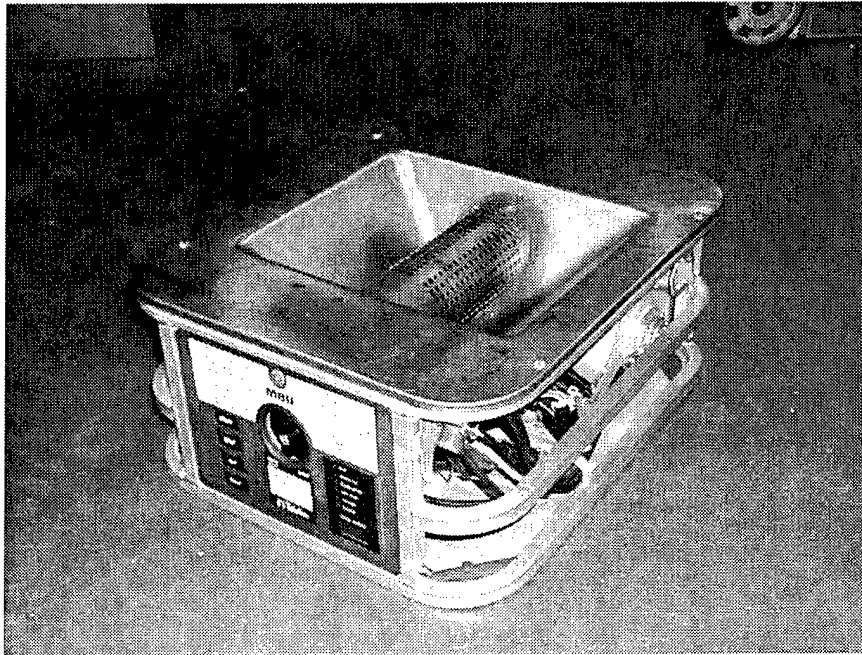


Figure 4. Modern Burner Unit

The first goal of this demonstration was to establish this baseline for a variety of performance characteristics relevant to current field-feeding practices so valid assessments could be made of the new equipment. The MKT with M2 burners is considered the current baseline configuration for military field-feeding. The MKT-I is a developmental item that has only been field tested in limited fashion. Nevertheless, it is the closest thing to replacement of the aging MKT and therefore was evaluated to provide a supplemental baseline.

The following characteristics were of primary interest:

1. Fuel consumption
2. Water consumption
3. Number of personnel required for various tasks
4. Time required to conduct various tasks
5. Equipment weight
6. Prepared food quality
7. Noise levels
8. Emissions

A second goal was to conduct a technical demonstration of the CHUCK Wagon prototype for comparison to this MKT baseline and characteristics of the MKT-I. Any additional human factors and/or safety issues observed during the cooking demonstration of the CHUCK Wagon system were documented.

Section 3 of this report summarizes results from the three tests; more detail and illustrations for each test can be found in **Appendices A through C**. Summary comparisons on noise level and emissions are contained in **Appendix D**. A complete study of kitchen weight and inventory for the three systems was conducted just prior to testing. The full results of that study are provided in **Appendix E**.

3. Methods, Assumptions and Procedures

Mock field-feeding scenarios were conducted for each of the three kitchen configurations at the Natick Soldier Center (NSC). Efforts were made to preserve consistency between tests with regard to the menu, food preparation method used, and other conditions such as weather and personnel.

3.1 Menu

The menu for each meal, consisting of sufficient food to feed 250 people, consisted of:

1. Twelve #10 cans of corn
2. Twelve #10 cans of baked beans
3. 250 hamburger patties
4. 250 hamburger buns
5. Chocolate cake
6. Peaches
7. Salad
8. Beverages (water, lemonade, coffee)

3.2 Environmental Conditions

Approximate ambient environmental temperatures during each demonstration were:

1. MKT with M2 burners – Sunny, temperatures in the mid-60's (°F) at the start rose to the mid-70's by the end.
2. MKT-I with MBUs – Sunny, temperatures in the mid-40's (°F) at the start rose to approximately 60°F.
3. CHUCK Wagon – Inside enclosed building with doors open for ventilation, temperatures were 50 to 55°F.

3.3 Location

The two MKT feeding exercises were conducted outdoors on a level surface of crushed rock. The CHUCK Wagon demonstration was performed in a covered but unheated breezeway, due to inclement weather.

3.4 Data Collection

Human Factors Engineers from the Ergonomics Team observed the demonstrations from beginning to end, unobtrusively collecting data throughout. Additional data relating to such factors as emissions was gathered by CHUCK Wagon project engineers.

Temperature were taken with Omega handheld digital thermocouple readers. Ambient air quality in the kitchens was measured with handheld sampling devices capable of monitoring CO,

CO₂ and O₂. Burner emissions and combustion temperatures were measured with the Quintox® flue gas analyzer shown in **Figure 5**. Light readings were taken with a photocell and digital readout device. Sound level was captured with a Extech 407740 sound level meter.

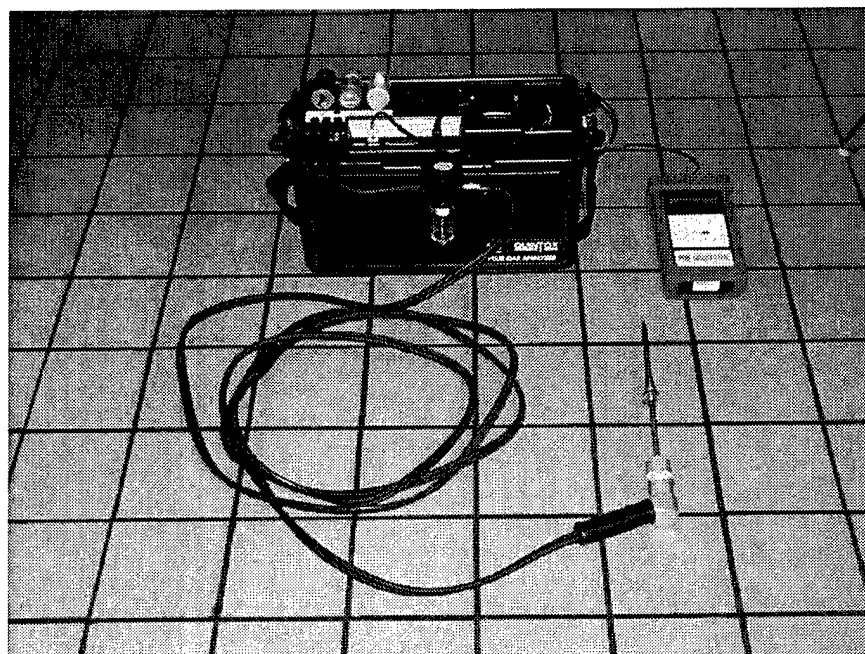


Figure 5. Quintox® Exhaust Gas Analyzer

4. Results and Discussion

Manpower and Personnel Integration (MANPRINT) findings and performance measurement results can be found in this section. Details and specific events for individual tests of each kitchen are synopsized in **Appendices A, B and C**. Information presented in this section is intended to give the reader an overview of the tests and, of more relevance, tables showing direct comparison between the kitchens. Findings are summarized in tables containing information on the logistical resources required, task time, noise, burner emissions, and appliance use.

4.1 Performance Summary

4.1.1 Logistical Resources

Logistical factors are summarized in **Table 1** and described in more detail in the following sections.

Table 1. Logistical Resources Required

Factor				MKT with M2s	MKT-I with MBUs	CHUCK Wagon
# Personnel				6		
Towing Vehicle				2 1/2 Ton		HMMWV
Weight		(lbs)		5754	6012	4607
Travel Cube	Length	(inches)		124		93
	Width			93		86
	Height			98		93
	Pintle			52		43
	Volume	(ft3)		654		430
#Parts				>270		90
Water Used				n/av		
Fuel	Type			Gasoline	JP-8	Diesel* (DF2)
	Burner(s)	Quantity	(gallons)	2.5	2.34	2.02
	Generator			n/ap	1.76	1.15

4.1.1.1 Personnel

Six cooks participating in each demonstration. They were a mixture of military and civilian food service personnel acting as the troops whose job it is to execute field-feeding tasks such as set-up, preparation, serving, cleaning, and, finally, pack-up of the kitchen system.

The same personnel were not available for each demonstration, but at least one individual, an experienced military food service MOS-92G-Cook, did participate in all three demonstrations. In the case of the MKT with M2 burners, there were two experienced personnel present.

Some of the individuals were quite familiar with all the food service equipment but not necessarily with actual field-feeding procedures. The remaining participants had limited degrees of experience and familiarity with the equipment and field operations. These personnel were directed to simply follow orders from those more experienced.

As such, the cooks shouldered varying degrees of responsibility, and, not all individuals participated in every task. Although all six assisted in setup, once the food was cooked, only two to three individuals participated in serving. Up to four personnel participated in the cleanup and packup activities for the MKT with M2 burners and the MKT-I with MBUs, while only two to three participated in the same activities for the CHUCK Wagon.

If conditions required, due to its simplicity and easy setup the CHUCK wagon could be operated more easily with less cooks than could the MKTs.

4.1.1.2 Equipment Weight and Parts

An exhaustive weight and inventory comparison for both MKT configurations and CHUCK Wagon is provided in **Appendix E**. The MKT, MKT-I and CHUCK Wagon kitchen trailers were outfitted with complete equipment inventories and then weighed to determine gross and tongue weight. The inventories were analyzed to assess number of parts and savings from one trailer to the next. The MKT inventory was developed from military doctrine. The MKT-I is a developmental item and inventory information was gathered from military doctrine and draft documents. The CHUCK Wagon is prototype equipment, so the equipment list was generated parallel with the study.

Comparing the MKT and the CHUCK Wagon parts inventories, the MKT has just over 270 parts and the CHUCK Wagon, 90. This savings is due to several factors inherent to the configuration of the CHUCK Wagon. These factors include the permanent attachment of some items onto the trailer itself, the integration of parts into the system, differences in quantity of some required loose items, and the elimination of items no longer required.

Generally, transport of any kitchen items aboard the towing vehicle, save food, is not required for the MKT, though often the fuel, burners and ancillary equipment such as tray pack heaters will be carried this way. In the case of the MKT-I, its generator must be stored

aboard the towing vehicle. The CHUCK shelter will likely be stored aboard the towing vehicle.

Each kitchen was weighed by setting it on scale pads positioned under each wheel and the pintle, as shown for example in **Figure 6**. The weight difference between the MKT and MKT-I is 250 pounds, in favor of the standard MKT configuration. The weight difference between the MKT and the CHUCK Wagon is 1143 pounds, in favor of the CHUCK Wagon. Besides being lighter, the CHUCK Wagon is towable by a smaller vehicle than the MKT.



Figure 6. MKT Suspended Above Scales

4.1.1.3 Water Usage

The cold water tank and kettles on the CHUCK Wagon were filled with a nearby garden hose. It is not clear how easy it would be to fill either in a field situation. The project engineer indicated that other than filling kettles the old fashioned way, by simply lugging 5-gallon water jugs, there are suction pumps aboard this kitchen capable of drawing water from jugs or a water buffalo. It is recommended it be verified these methods in fact work.

Water usage was not calculated during these cooking demonstrations. While every attempt was made to simulate true field conditions, water buffalos, which could have allowed for more accurate accountability of water usage and time consumption, were not used. Instead, water for food preparation, beverages, clean-up, etc. was dispensed from hoses available at the evaluation locations. From purely an observational viewpoint, it did not appear that the water usage varied significantly amongst the three scenarios. The same quantities of water were required for most aspects of the cooking and cleaning operations; however, if

pressurized water hoses were not available, the process of getting water to the MKTs would have been much more intense.

4.1.1.4 Fuel Usage

The types of fuel used in each demonstration differ due to the requirements of each cooking system. JP-8 fuel and diesel fuel were used for the MKT-I with MBUs and the CHUCK Wagon demonstrations, respectively. Gasoline was used in the MKT with M2 burners demonstration.

During the MKT demonstration, six M2 burners were used for the various cooking appliances. These burners were filled with motor vehicle gasoline (MOGAS) and weighed before cooking began. After all cooking was completed, the burners were weighed again to determine how much fuel was consumed. It was determined 14.6 pounds of fuel was consumed. As gasoline has a density of 5.87 pounds per gallon, this amounts to 2.5 gallons.

Similarly, the amount of JP-8 fuel consumed during testing of the MKT-I with MBUs demonstration was monitored. The burners used 15.44 pounds, and the generator used 11.59 pounds, for a total consumption of 27.03 pounds, or 4.1 gallons. The MKT-I generator is shown in **Figure 7**.



Figure 7. MKT-I Generator

For both MKTs, the burners had to be filled, one by one, on-site 50 feet from the trailer. The situation is similar with the MKT-I; however, future procedures for the MKT-I might involve allowing the burners to be filled at the depot beforehand and transported full so they are ready to go. The CHUCK Wagon burner and generator are permanently connected via

hoses to two 5-gallon diesel jugs transported on and used from the trailer tongue (**Figure 8**). One jug is for the burner and the other for the generator. The weight of each tank was taken before and after cooking to determine total fuel consumed. The generator used 8.23 pounds, while the burner used 14.39 pounds, for a total of 22.62 pounds or 3.17 gallons.

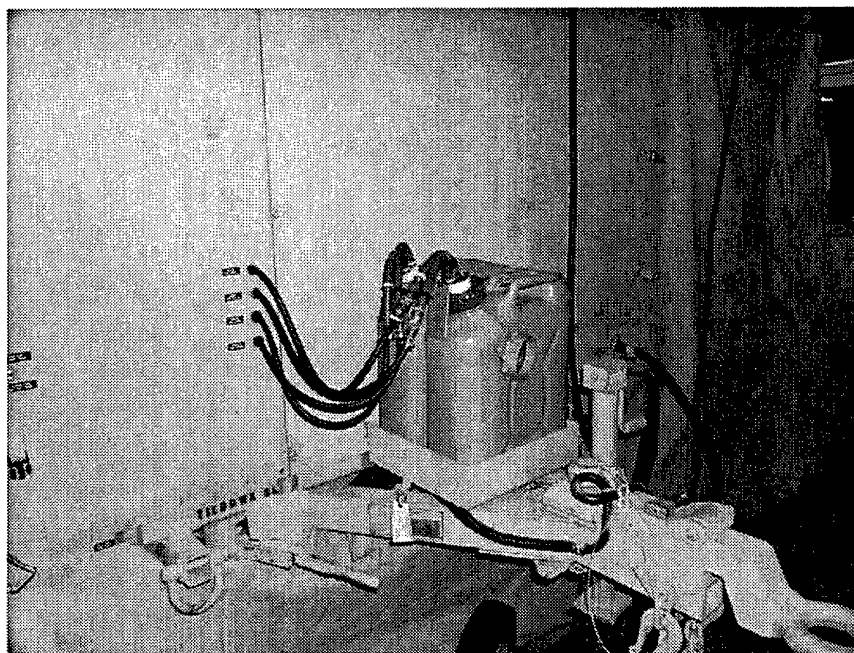


Figure 8. Permanent Location of Fuel Cans on Tongue of CHUCK

4.1.2 Timed Events

Specific times for many of the most important tasks are summarized in **Table 2**. Further discussion about these times follows.

4.1.2.1 Overall

The overall total time indicated for each demonstration reflects the moment that the test participants began to deploy the kitchen facility to the moment it was completely packed and closed. Events listed in the table overlap since several people participated and had different jobs throughout the exercise, therefore individual task durations will not add up to the overall time taken for the meal.

As can be seen, the MKT with M2 burners took the longest at 315 minutes. The MKT-I took 301 minutes, while the CHUCK Wagon took the least amount of time, 287 minutes.

Table 2. Summary of Task Times

Task	Duration		
	(minutes)		
	MKT with M2s	MKT-I with MBUs	CHUCK Wagon
Setup	86	99	13
Prepare and cook	177	140	148
Cook Beans	40	52	20
Cook Corn	29	52	20
Bake Cakes	40	46	56
Cook Hamburgers	84	75	83
Heat Beverage Water	47	46	21
Cleanup	82	64	84
Pack-up	Elapsed	55	75
	Actual	50	45
Overall	315	301	287

4.1.2.2 Setup

Setup included the following tasks:

1. Level
2. Open
3. Assemble Shelter (roof, floor and sidewalls)
4. Prepare Burners (fuel, preheat when necessary, and light)
5. Organize (unpack and distribute pots, utensils etc.)

Setup times varied significantly for each demonstration. The MKT-I with MBUs took the longest at 99 minutes. MBUs are easier to use than M2s and so it was expected that the MKT-I would be quicker than the MKT. But a problem was encountered with the fuel filling mechanism. More experienced operators and the right equipment would have saved considerable effort for this task.

The MKT with M2 burners took 86 minutes to setup. Again, quicker setup may have been possible with more experienced personnel, particularly with regard to installing the awnings and screens. Initially they were installed improperly and had to be re-done.

The CHUCK Wagon took the least amount of time at 13 minutes. Time savings was due to differences in shelter setup and burner initiation. The roof section of the CHUCK Wagon consists only of three awnings that hinge at the roof, but the shelter setup time in this case neglects installation of sidewalls; at the time of demonstration, sidewalls were unavailable. Subsequent testing showed the sidewalls can be installed in less than 5 minutes. Burner initiation is *much* simpler on this kitchen. The MKT and MKT-I require six burners to be fueled, lit, and installed; the CHUCK Wagon only requires two switches be flipped (Figure 9).

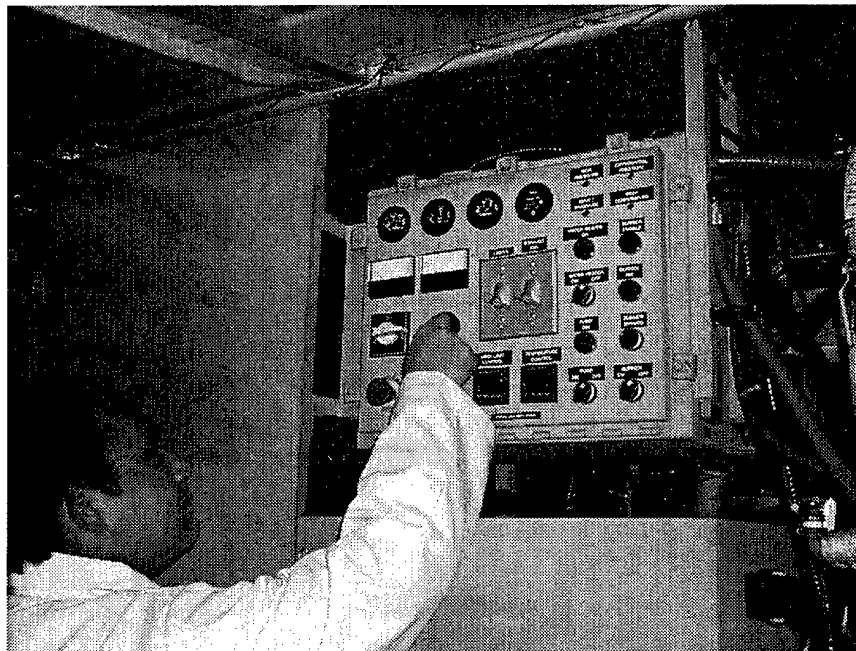


Figure 9. Starting the Engine and Burner

4.1.2.3 Prepare and Cook

The overall time it took to cook the entire meal began when food preparation started, until the last item was fully cooked. In all three exercises, this was when the last hamburger was taken off the griddle.

The MKT with M2s took the longest at 177 minutes, with the CHUCK Wagon taking the second longest at 148 minutes, and the MKT-I with MBUs taking the least amount of time (140 minutes).

The time to warm corn and beans varied with each exercise. These precooked items simply need to be reheated; they are done when hot and bubbling; no temperatures were taken. The times noted for beans, corn and preparation of the hot water using the CHUCK Wagon are lower than either MKT. But it should be noted that while the meal plan included twelve cans each of corn and beans, this was not followed strictly. Twelve #10 cans each of the

corn and beans were cooked on the MKT with M2 burners, while twelve cans of beans and ten cans of corn were cooked in the MKT-I with MBUs. On the CHUCK Wagon only six cans of each were heated. There is no explanation for this though the CHUCK Wagon kettles certainly have ample capacity. It is confidently assumed since the corn and beans cooked so quickly, the kettles could handle cooking double the quantity in less than or equal to double the time.

While comparisons should not be made between vegetable heating times, this discrepancy does not affect overall meal preparation and cooking times, because cooking hamburgers overshadowed all other tasks. All other foods were prepared in parallel and in less time than the hamburgers and therefore did not affect meal duration.

The time to bake cakes is hard to compare because oven operation can vary considerably with a cook's preferences and talent, though cooking in the CHUCK convection oven is vastly less difficult. For instance, the M59 range cabinets on the MKT require that cake pans be constantly rotated. The uneven and high temperatures in these ovens sear the exterior and can make cakes appear done before their time. During this test, when cakes were removed from the oven and cut, they were found to be still uncooked inside. Times when cakes were removed and replaced into the ovens were not documented.

False alarms were not a problem with the CHUCK Wagon convection oven and there was no requirement for periodic rotation. Additionally, the size of cake pans used during the CHUCK demonstration was larger than those used in the M59 range cabinet. Still, it would be fair to say the difference in times required to cook cakes from one demonstration to another was not significant.

The times to cook the hamburgers did not vary considerably. They ranged from 75 minutes using the MKT-I with MBUs, to 83 minutes with the CHUCK Wagon, and 84 minutes with the MKT with M2's. The griddle used on both MKTs was the same. But the MBUs tended to heat the griddle surface more than either M2s or the CHUCK Wagon's thermal fluid.

4.1.2.4 Serving

Food serving operations were virtually identical for both MKTs. The serving process was a "straight line feed", that is, individuals walked up the steps onto the MKT and were served hot food (hamburgers, corn and beans) by two personnel; they exited the opposite set of steps and passed two (30"x72") serving tables outside where salad, peaches, cake, beverages, condiments, etc. were available for self-serve. These two tables were the modern replacement for the standard 48-inch tables.

Serving with the CHUCK Wagon was similar; most food was doled from two tables that are part of the CHUCK inventory. They were set up on the ground directly in front of the platform flooring near the griddle area. Two cooks served hamburgers, corn and beans from behind the tables. The salad, cold beverages and condiments were placed on the end for

self-serve. There was no room on these tables for the cakes, coffee, peaches and condiments. These items had to be served from additional tables not supplied with the CHUCK Wagon.

There appeared to be no significant differences between the three serving scenarios and time to serve was not impacted by the different methods. Actual serving times are not compared in this report since the flow of consumers was variable, and though enough food to feed 240 people was prepared, there were not 240 diners available.

4.1.2.5 Cleanup

The cleanup tasks for each kitchen configuration were fairly similar, consisting of washing down all kitchen surfaces. The process in each case was dominated by washing pots, pans and utensils, although that was done at a nearby sanitation facility, as it would be in the field. While the times for cleaning the MKT with M2 burners and the CHUCK Wagon were close at 82 minutes and 84 minutes, respectively, the cleaning of the MKT-I with MBUs took up to 20 minutes less at 64 minutes.

The 20 minute difference between the MKTs is attributed to a mess created by the griddle. While cooking hamburgers with the standard MKT, griddle grease was not draining properly into the standard issue grease trap/container. The cook had to quickly jury-rig a new system to prevent spillage, but this did not work as well as expected. Cleanup afterwards of congealed grease surrounding the griddle base was time consuming.

During cleanup of the CHUCK Wagon not all participants were available to help, thereby increasing the time required.

4.1.2.6 Pack-up

Two values are presented for pack-up. The first value, "elapsed time", was measured from when pack-up began until it was completed. The second value, "time on task", is the amount of time personnel were actively working. This distinction is necessary because there were times when personnel had to cease packing the kitchen and wait for pots, pans, and utensils to return from the sanitation facility. So for purposes of comparison, the "time on task" value is the most relevant.

For both MKTs, the pack-up procedures are very similar as reflected by the duration of each (50 minutes and 45 minutes). The CHUCK Wagon design permits easier and quicker pack-up, and was completed in 30 minutes. This time may have even been less if all personnel had been present for the duration of the exercise.

4.1.3 Food Quality

Formal questionnaires and interviews of consumers were not conducted; however, it appeared that the quality of food from each demonstration was consistent. There were no

under-cooked or over-cooked items. Informal discussion with cooks and consumers indicated there was no difference in taste or quality.

4.2 MANPRINT

4.2.1 Air Quality

Air quality is effected by the balance of two variables; area ventilation, and gaseous products generated either from cooking food or the heat-source combustion process. During testing an attempt was made to measure air quality, but results are withheld from the main body of this report due to lack of confidence in the instrument accuracy.

Since combustion gas entering the kitchen would be a direct and major pollution contributor, exhaust from the burners used in each trailer was monitored. It is widely accepted that the venting of burner combustion products in the vicinity of people is unwise; despite complete ventilation there remains a danger of cooks directly inhaling fumes leaking around the edges of appliances. These notes on factors effecting air quality are summarized in **Table 3**, sans quantitative results, though more details of these measurements can be found in **Appendix D**.

In general the CHUCK burner is more efficient than either MKT burner and vents its exhaust outside the cooking area. It also includes a hood to vent other gaseous cooking products such as steam and airborne grease outside the trailer.

4.2.2 Noise Levels

Noise level was monitored throughout the demonstrations of both MKTs. Since CHUCK Wagon testing was done in a confined area, it was necessary that noise level measurements from previous tests be used. A detailed comparison of noise level for the three kitchens can be found in **Appendix D**. A summary of results is found in **Table 4**.

In the MKT with M2 burners, the noise amounted to a 70 dB-A hiss and peaked at 72 dB-A. This was measured at head level centered within the cooking area. In the same location the MKT-I with MBUs was an 82 dB-A growl. At this volume, it was difficult to hear clearly and participants felt the need to shout. The CHUCK Wagon was a 72 dB-A rumble. Subjective/perceived sound intensity validates these measured numbers.

Table 3. Environmental Factors

Factor		MKT with M2s	MKT-I with MBUs	CHUCK Wagon
Noise	(dB-A)	70	82	72
Emissions		Gasoline exhaust vents into kitchen shelter	JP-8 exhaust vents into kitchen shelter	Diesel or JP-8 exhaust vents out roof of shelter

4.2.3 Human Factors

The following human factors observations regarding the CHUCK Wagon are provided, with the intent to assist future equipment developers in making design improvements.

4.2.3.1 Flooring

During setup, a flooring system stored on the back of the trailer (**Figure 10**) is installed along the full length of the deployed kitchen on the two sides where cooking and food preparation takes place. The platform provides a good surface to keep cooks separate from mud, rocks, cold etc. The support feet are fully adjustable to accommodate uneven terrain. The distance from the platform to the working surface is an acceptable 37".

The flooring width is 47 ½" allowing plenty of room to prevent danger of stepping off the sides. There is, however, a potential trip hazard in that the support feet tubing extends 6 inches above the floor at each corner of the two platforms. It is recommended that either the tubes not protrude up through the platform, or the system be redesigned.

When the flooring platform is not in place around the CHUCK Wagon, a step stool is needed for whomever is raising the awnings. It is recommended that personnel be trained to install the flooring prior to raising awnings.

Due to spilled grease, the flooring surface began to get slippery. It is recommended a slip resistant, yet easily cleaned surface be found.

During transit, flooring it is stored on the back of the trailer. As each section is set on the supporting shelf, someone must hold them, or they will fall. If a section fell, it might cause serious injury. It is recommended the shelf be designed to prevent this.

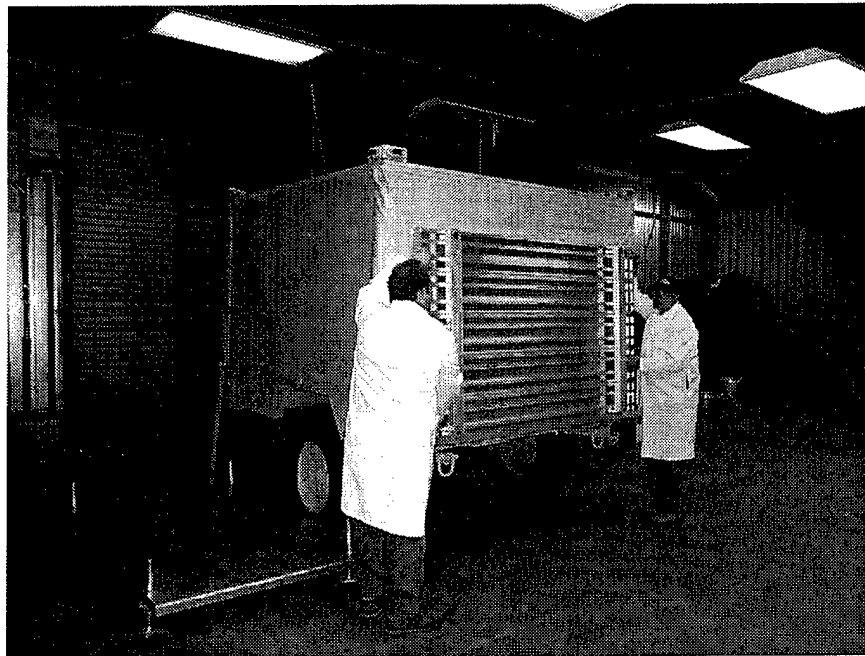


Figure 10. Removing Flooring from Rear of Trailer

The sections set on the shelf were secured via bungee cords. In future designs the bungee method will not be used, sturdy hooks and winch strap will take its place. This method should then be verified for its adequacy and its ability to sustain rugged transport.

4.2.3.2 Shelter

It is recommended that suitability of the CHUCK in other than fair weather conditions be evaluated. For instance, when the exhaust fan is on, cold air will be drawn up from the ground underneath the trailer, despite the accompanying ground skirt. While cook's upper bodies will gain some amount of warmth from appliances, their legs could get very cold. For instance, temperature stratification was an issue with the MKT even though it does not have an exhaust hood drawing warm air off the top of the kitchen. This problem prompted the addition of an air circulation system to the MKT-I. In hot weather, however, the CHUCK Wagon exhaust fan may provide for *more* comfortable temperatures.

Although the CHUCK cooking area can be fully enclosed with sidewalls, the serving line is exposed in its current configuration; this may prove unacceptable in some weather conditions. It should be noted that food serving from the MKTs is often done outdoors, and though there is sufficient room in the kitchen to always permit the feeding line to pass through, there is little room for ancillary items such as beverages and condiments. These are usually served from a second kitchen or separate tent.

The task of installing the side walls on the CHUCK Wagon was not performed during this demonstration. An evaluation of this should be documented.

During installation and removal of pins in the awning corner supports, a hammer was required. It is recommended the tight fit be relieved enough that the pins may be manipulated by hand.

When lowering the awnings and securing them to the outside of the trailer, it was difficult to grasp and secure the female ends of the buckles. A small pull-strap would be useful, especially if troops wore gloves.

4.2.3.3 Appliances

A summary of appliances on each kitchen is summarized in the table below. All CHUCK appliances are permanently mounted aboard the trailer and mounted flush with an easily cleanable stainless steel counter top. Discussion of each appliances follows.

Table 4. Summary of Appliance Description

Appliance	Comments		
	MKT with M2s	MKT-I with MBUs	CHUCK Wagon
Griddle	Aluminum, remove from trailer to clean	Aluminum, non-stick, remove from trailer to clean	Stainless Steel, perm. attached to trailer
Kettle	30 gallon total capacity, aluminum, bottom heating	30 gallon total capacity, aluminum, bottom heating	40 gallon total capacity, stainless steel, even heating
Oven	High uncontrolled temperature, requires rotating product	High uncontrolled temperature, requires rotating product	Thermostatically controlled convection oven
Hot Water Tank	Not Included	Not Included	20 gallon capacity, thermostatically controlled, running
Generator	not required	loud, separate from kitchen	very quiet, integrated with trailer

Griddle

The CHUCK griddle with a full load of burgers is shown in **Figure 11**. A grease trough $\frac{1}{2}$ " wide and $\frac{1}{4}$ " deep runs along the front edge. Ideally it prevents overflow and helps direct grease into the 3" wide, 3" deep trough running along the right side of the griddle from front to back. The trough along the front edge was too shallow to prevent overflow or effectively funnel the grease. It is recommended that this trough be made deeper, or a sidewall be put up, and a similar trough be included along the back of the griddle.



Figure 11. CHUCK Wagon Griddle

At the rear of the 3" trough is a 2" drain hole penetrating to the trailer bottom. At the time of testing there was no special provision installed to catch grease draining out this hole, so an empty #10 can was used and found to be adequate for the 250 hamburgers cooked. A suitable grease collection device was installed soon after testing (**Figure 12**). It consists of a tray that during transport clips to the trailer bottom. Without looking and with one hand, a soldier can free the tray and allow it to swing down on hinges. The tray will support #10 cans, Cambro inserts (as in the figure), and empty traypacks, so disposable containers of sufficient capacity are readily available at all times. The cooks must be trained to ensure a container is always in place prior to using the griddle; this will prevent hazards associated with allowing grease to spill on the ground.

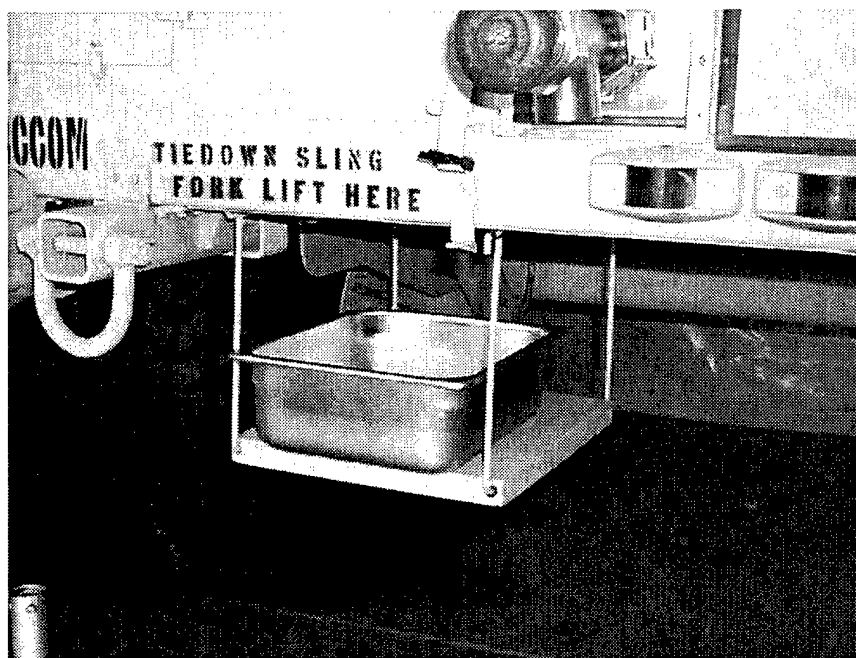


Figure 12. Shelf for Grease Collection Tray

To promote the flow of grease into the 3" trough, it was necessary mid-meal to re-level the trailer and provide more griddle incline. It is recommended that the leveling bubbles provided on the kitchen be calibrated to ensure appropriate griddle tilt while maintaining adequate level of the kitchen as a whole.

The griddle needs a higher backsplash such as that on the MKT griddle shown in (Figure 13). During scrape-down between hamburger batches, grease sloshes over the backsplash into areas behind the griddle and left kettle. In addition to increasing the cleaning burden, there is the possibility of a grease fire, although absence of ignition sources in this kitchen makes this very unlikely.

It is recommended the exhaust fan grease trough above the griddle cooking area be evaluated for its utility. It appeared to be interfering with airflow into the exhaust fans and adds more surface to be cleaned.

The griddle temperature control knob is not correctly calibrated. At first, during hamburger preparation the control knob was set at 350°F, but in less than 10 minutes the surface temperature at the griddle center was 388°F. 20 minutes after the control knob was lowered to 300°F, griddle temperature returned to a more reasonable 360°F. It is recommended the dial be properly calibrated.

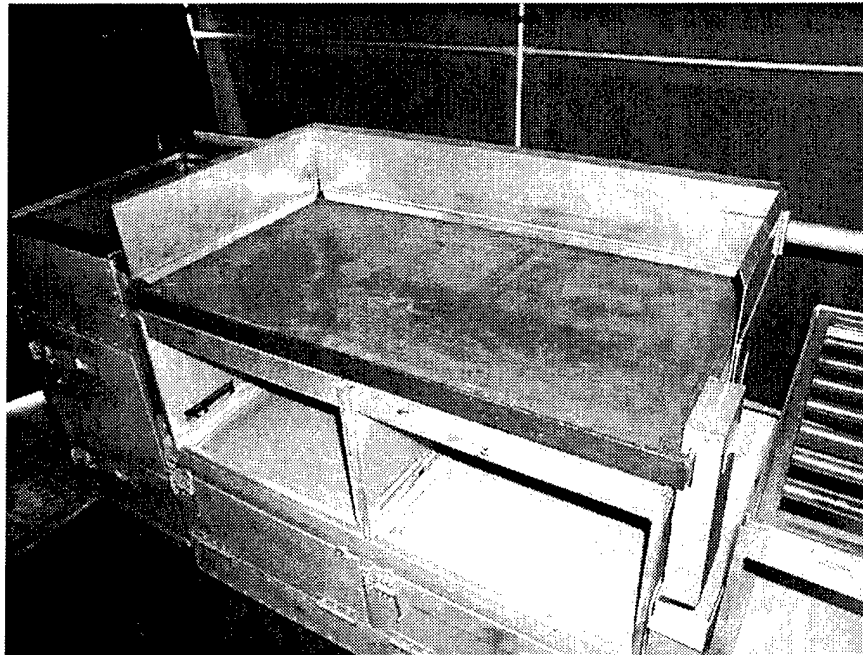


Figure 13. MKT Griddle

Oven

The CHUCK Wagon uses the commercial convection oven shown in **Figure 14** for quick and efficient baking with even temperature distribution. It offers as much cooking space as both MKT M59 range cabinets (**Figure 15**) but in a much smaller package. Unlike range cabinets which require constant monitoring and frequent shifting of the contents, the convection oven allows for accurate temperature control and extremely even cooking with little cook effort.

An interior light is recommended for the CHUCK oven. And, although the oven has a timer buzzer, the cooks never heard its signal. It is recommended a louder buzzer or integrated flashing light be installed.

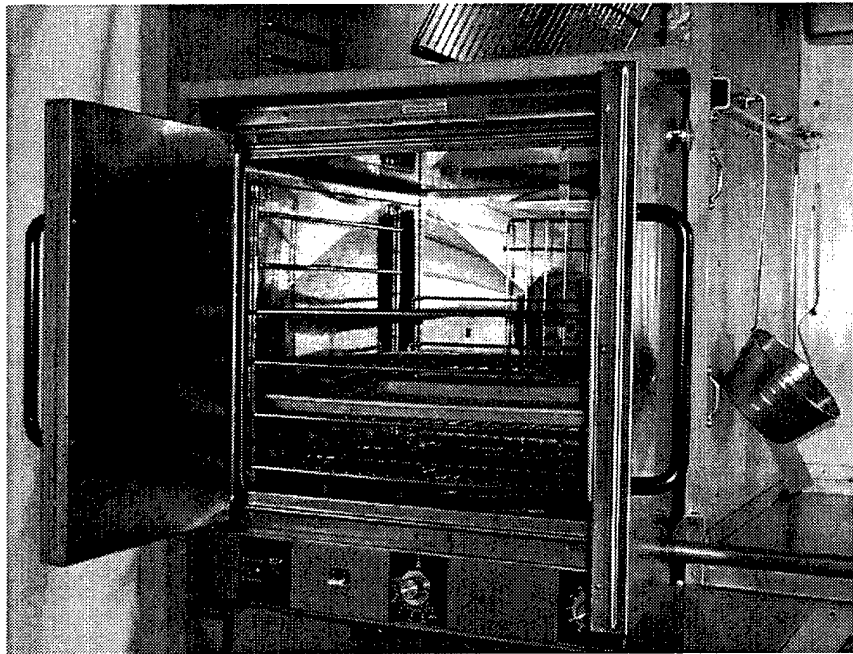


Figure 14. CHUCK Wagon Convection Oven

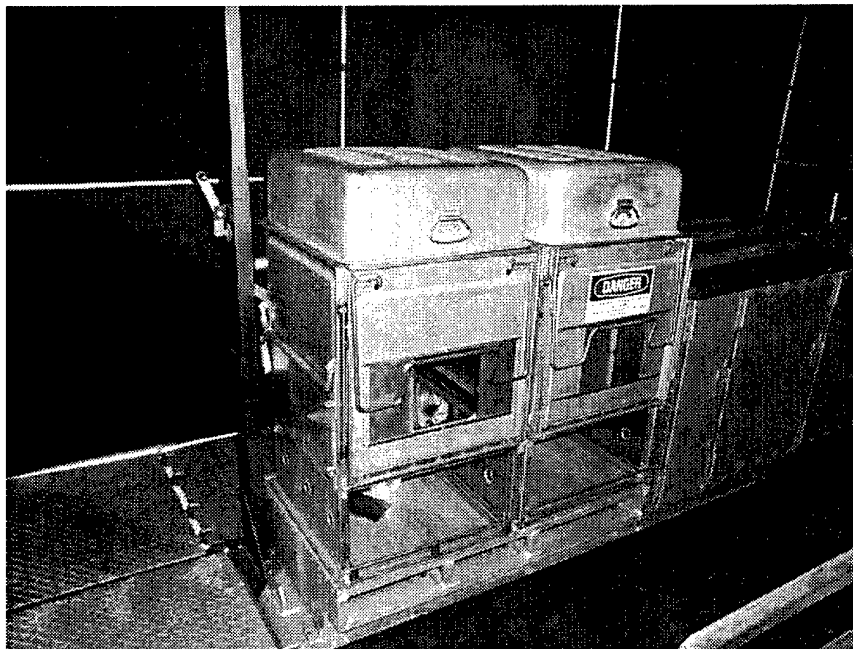


Figure 15. M59 Range Cabinets Used Aboard MKTs

Kettles

The CHUCK Wagon kettles (**Figure 16**) are commercial, all stainless steel 20-gallon models. They represent a significant improvement over the thin aluminum 15-gallons pots MKT cooks are used to placing over burners which often scorch the food. The CHUCK kettles heat evenly from all sides and drain through the bottom.

From a cook's perspective, *simmering* in the kettles is difficult because the thermostat cannot be turned down enough; food scorches on the edges and sides. A better heat control is being researched.

Ladling beans from the kettle to a Cambro serving tray was a bit awkward and required two people because there is no place to rest the Cambro while one person is ladling. This was solved by placing a table against the trailer, but this solution is not optimal. A food container support system is currently being designed.

During the exercise cooks tried to empty the kettle of corn through the drain spigot and it quickly clogged.. With this type of spigot, even if the contents had a sufficiently low particulate size and viscosity to flow, the valve tends to splatter and could burn cooks. Although the drain configuration is NSF approved, it was difficult to clean. The straight through ball valves on the Rapid Deployment Kitchen allowed a variety of dishes to pass through, they were easy to unclog and easy to clean. It is recommended the kettles be drained only when there are no large food particles, with the spigots removed, or during cleaning.



Figure 16. CHUCK Wagon 20 Gallon Kettles

During transit, the spigot valves are removed, leaving stubs. If cooks neglect to close the weather tight doors over the drain egress areas, the stubs could become dirty and dirt could enter the kettles. Luckily they are easily cleaned.

The lid for the right kettle would not stay open by itself and had to be tied up to keep it in place. It is recommended the design be changed to improve ability of the lid to stay open. The kettles come standard with friction-type lid restraints, but they wear out.

If the kettle drain spigots are removed, allowing anything to drain from the kettle, it will spill over the taillights. Although the taillights are weather resistant and water tight it might be difficult to clean food off them, and high temperature liquid may damage the plastic parts.

Even when off, the kettles can retain a significant amount of heat along the bottom and sides, so when food is drained from a kettle, any remaining film will cook onto surfaces making cleaning difficult. However, an advantage to this is if the kettles are immediately filled with soap and water the heat retention quickly warms the water to a temperature suitable for sanitation.

Sink

Similar to the griddle grease drain, the hand sink hole has nothing below to catch graywater. During this demonstration, a pot was placed underneath and according to the project officer, this method is being considered as an acceptable method since incorporation of plumbing would add weight, cost and maintenance. And, being able to observe the pot filling up knowing they have to empty it themselves, would hopefully encourage troops to conserve water.

The ease or difficulty for personnel to remove a full pot of water and drain it in a suitable location should be examined. Also, would this open pot of dirty water attract bugs and rodents, creating a health hazard? If this method is deemed acceptable, it is imperative cooks be trained to always place a pot below the sink and then dispose of the water appropriately.

4.2.3.4 Tables and Serving Procedures

The two tables supplied with the CHUCK Wagon provided a dual purpose. Initially, they served as extra counter space during food preparation. Later, they were used for serving.

The tables could easily be moved and were used in a variety of ways. At first they were placed parallel to the griddle and oven, and parallel to the kettles allowing enough space on the platform to move easily around the cooking area. In this configuration such activities as mixing the cakes, opening the beans and corn, and staging of uncooked hamburgers took place. Later, during grilling, the table parallel to the kettles was pushed against the kettles to provide a staging area for cooked hamburgers. While this facilitated hamburger movement,

the table then blocked kettle access. In this case, it was not initially a major issue, since the vegetables had already been heated and the kettles turned down or off, but at some point before all hamburgers were cooked, the table pushed against the kettles had to be moved and placed in a serving location. This allowed participants to start setting up a station and transfer the corn and beans to Cambros, but the griddle cook then had to twist his body 180° to put burgers on the table behind him thus dripping grease on the floor. A drop-down countertop near the griddle could solve this problem. Some effort has been put toward addressing this issue.

Because both tables were monopolized during preparation and cooking, there was no place to put the cakes as they emerged from the oven. The storage cabinet above the oven can get quite hot, so following this testing, shelving was added to this storage area to provide a warming and holding area for oven product. Even so, there was still no room for coffee or peaches.

4.2.3.5 Miscellaneous

An electrical outlet is provided in the griddle control panel. The experienced food service personnel present indicated he did not know what it would ever be used for. This is reasonable because electricity availability is currently uncommon in the field, but a few possible electrical appliances that might be useful are a meat saw, an electric knife, a can opener, a microwave, a coffee maker, or a device to recharge batteries.

The acceptability of these appliances would need verification from the points of view of doctrine, safety, and practicality. For instance, if a microwave were available, where would it sit, and how could its placement, or the orientation of the plug be arranged to prevent tripping or snagging on the cord? Furthermore, if a requirement for an outlet is accepted, it is recommended that it be GFI (Ground Fault Interrupt) protected and include a NEMA cover plate to minimize water or food intrusion when not in use.

A few hooks are present for hanging utensils in the cooking areas. It is recommended that long racks or rails be provided to increase space and make it easier to hang items.

The switch for the exhaust fan is located around the side of the CHUCK Wagon at the main control panel. It would be easier to use if located in the kitchen area. The manpower requirements of this kitchen need to be assessed. For instance, will the same number and types (by qualifications/MOS) of personnel be required to maintain and repair the system in the event of malfunction? How much preventive maintenance and repair is required? What is the Mean Time Between Failure and is it appropriate to field use. An advantage of the MKTs is their simplicity and reliance on multiple burners that can be easily replaced.

Appropriate training methods and materials must be developed for both operation and maintenance.

5. Conclusions

This section interprets findings presented in the previous section. It highlights improvements the CHUCK Wagon offers over current field-feeding equipment, and points out weaknesses or areas for which improvement is still desired. Recommendations are made, and some comments are directed toward the benefit of future tests.

The information is organized by five critical areas for comparison, thus painting a broad picture of equipment effectiveness. These characteristics are: mobility, deployability, usability, safety/health, and energy consumption. Naturally, there will be overlap. Two additional characteristics, reliability and maintainability, remain unknown and must be assessed over the years this system is operated and maintained.

Factors affecting mobility are: equipment weight, towing vehicle required, and stowed volume and footprint area. Deployability is covered by: deployed area, setup and breakdown time, and the number of personnel required to perform these actions. Factors which affect usability are: the number of personnel required to operate the kitchen, time on task, complexity, flexibility, and capability. Ease of use is broken down by appliance.

5.1 Mobility

In line with the U.S. Army's goal of improving equipment rapid deployability, the CHUCK Wagon represents a significant step forward. Once packed, it displaces only 400 cubic feet and covers 55 square feet; almost 40% less volume and 25% less area than the MKT. This, and a 20% weight savings over the MKT, allow for more efficient stowage and transport by sea, air, or rail. The CHUCK is 3 feet shorter, and 1 foot narrower making it more maneuverable. By ground, it is towable by HMMWV, a much smaller asset than the 2 ½ ton truck needed for the MKT.

5.2 Deployability

The simplicity of CHUCK Wagon setup and breakdown is a vast improvement over current kitchen trailers. The number of cooks participating in this demonstration was held, per doctrine, at six, but if conditions required, the CHUCK Wagon could easily be setup by two people. And even with just two, the kitchen design permits quicker deployment and pack-up. Both were accomplished in a fraction of the time needed for the MKT.

5.2.1 Shelter Assembly

Theoretically, setup by two personnel is possible with an MKT, but at considerably greater effort and time compared to the CHUCK. With the MKT, cooks must crawl on the ground under the trailer to lower four jacks which can be stiff with corrosion. Next, very heavy floor sections, hinged at the trailer sides, are lowered and must be held in place while fitting support poles underneath. Cooks then clamber onto the platform and as they assemble

equipment must dig through the tangled pile of tables, poles, roof jacks, steps, floor mats and Cambros that fill the center aisle.

Aboard the CHUCK Wagon, the flooring system is mounted to the trailer rear. The light, aluminum platforms are simply lowered from the shelf they rest on, feet are installed, and the cooks need only move a few feet to set the pieces in position. Three jacks are then installed on the trailer for leveling. Lightweight awnings, hinged at the roofline, are swung up and locked into place, and a sidewall is attached to the awnings to create a full enclosure. All the loose component parts are tied down to the griddle and kettle deck and are easily accessible.

The total area required for a deployed MKT camp is 338 square feet. This includes three satellite stations, but not the 50-foot pathways leading to them. These stations effectively make the camp much larger, and in certain terrain the clearing of vegetation could be difficult. The total CHUCK footprint is only 85 square feet, and it requires no auxiliary real estate.

5.2.2 Burner Preparation

The burners aboard the MKT are not accessible until the center aisle has been cleared. While this is being done, the three separate stations for filling, lighting, and fuel storage are established in the area surrounding the trailer. The burners are carried to the filling station, then over to the lighting area, and again, another 50 feet, while lit, back to the trailer. MBUs use JP8 fuel which is safer and more logistically supportable than gasoline, though of questionable safety to the human nervous system. Compare this to diesel fuel which is relatively benign, unless directly ingested. These burners do not require a lighting area and do not need to be carried while lit because they can be started automatically even while installed in kitchen appliances. As with other MKT-I equipment, they require electricity, so a generator must be fueled and situated some distance from the trailer.

When setting up the CHUCK Wagon, cooks need not touch a drop of fuel, carry any burners, or connect to a generator. The two, standard, 5-gallon fuel tanks can be filled at depot and are connected to the equipment via hoses, so they may be transported and used right from their stowage point on the trailer tongue.

The CHUCK Wagon has a single reliable commercially-available burner, in contrast to the expensive, multiple, military-specific burners required aboard the MKT, and it can burn diesel or JP8. Alike the MKT-I, the CHUCK requires electricity, but the generator is mounted permanently aboard the trailer. The genset is started simply by turning a key, and the burner is initiated by flipping a switch. The rest is fully automatic. The burner and generator can be initiated even before any unpacking or setup of the trailer has begun, so cooking can begin immediately.

5.3 Usability

5.3.1 Inventory

The number of loose parts in any equipment system significantly impacts usability. Storing, locating, keeping track of parts, and the inconvenience created when a part is missing, adds to work load and can jeopardize a mission. The MKT has just over 270 parts and the CHUCK Wagon, only 90. Almost all these parts can be stored aboard the kitchens during transport; however, the MKT-I generator must be put with the towing vehicle. Similarly, there is no room for the CHUCK shelter sidewall aboard the kitchen itself.

5.3.2 Appliances

All CHUCK Wagon appliances are made of stainless steel, permanently mounted to the trailer, and surrounded by a stainless steel countertop. Therefore, they are exceptionally easy to clean and more sanitary than the MKT. During cleaning of the MKT, for instance, large parts of the of the kitchen were dismantled and transported to the sanitation facility while cooks used paper towels to clean food from crevices throughout.

Included with the CHUCK is a small sink with hot and cold running water cooks can use to wash food items, utensils, or, more importantly, their hands. This sink is equipped with a pressurized sprayer to quickly dispense water during meal preparation, or for cleaning appliances and flooring. The MKT has no such device, and does not have pressurized water.

There are no temperature controls on any of the MKT appliances. Some moderation can be obtained by adjusting the burners, but still, cooks must pay close attention to what they are doing lest they burn the product. All appliances aboard the CHUCK have temperature controls, and there is a timer on the oven. It is recommended the CHUCK timer buzzer be louder.

5.3.2.1 Oven

The CHUCK Wagon uses a commercial convection oven for quick and efficient baking with even temperature distributions. It offers as much cooking space as both MKT M59 range cabinets combined, but in a smaller package.

The MKT range cabinets have no temperature control and run very hot (550°F during this test) requiring constant monitoring and frequent shifting of the contents. During this test the burner actually melted some aluminum baffle plates that were part of the oven. Furthermore, since the burner is directly beneath food contents, exhaust products are in direct contact with the food, and, a mishandled tray could dump food directly onto an open flame. This would never happen with the CHUCK oven; any spilled food would be completely contained within the stainless cavity, and would not impinge on any heating element.

5.3.2.2 Griddle

The CHUCK Wagon griddle was easy to use and clean, but the trough along the front edge was too shallow to prevent grease overflow, as was the backsplash. It is recommended the CHUCK griddle be redesigned with the addition of retaining dikes.

Still, it made for less of a mess than the MKT griddle; while the MKT griddle contained splattering grease better, its drain and grease collection bin was inadequate to the job and caused a mess during testing.

The very heavy, and hot, MKT griddle also had to be removed from the kitchen after the meal and carried by two cooks to the sanitation center.

5.3.2.3 Kettles

The overall performance of either MKT configuration is limited by the use of military unique burners and appliances which are not thermodynamically optimized. For instance, testing of individual MKT appliances showed each 53.5 kBTU/hour burner can heat water in a 15-gallon stock pot at a rate of 15 kBTU/hour for an efficiency of 28%. Identical testing with the MBU burners showed a kettle heat input of 19 kBTU/hr at a net efficiency of 31%. Because there is no method for temperature control, cooks must be careful not to burn anything in the pots as this heat enters entirely through the bottom surface.

The CHUCK Wagon kettles each hold 20 gallons and measurements show their contents can be heated at 55 kBTU/hour; 3.7 times faster than the MKT and 2.9 times faster than the MKT-I. The contents of the kettle are heated through 2/3rds of the kettle surface area, thus minimizing the possibility of carbonized food product. It was found the CHUCK kettles could only be turned down to a minimum temperature. This makes warming or simmering difficult, so efforts are underway to modify the thermostats for lower ranges.

An advantage of having separate kettles as on the MKT is that several of them could be filled with a variety of products while awaiting serving. If such a strategy were used aboard the CHUCK, the kettles would have to be emptied and then washed before another type of food was introduced. It could be argued this is what happens when food is transferred to insulated food containers for holdover; however, food cannot be reheated in insulated food containers.

5.3.2.4 Tables

The two tables supplied with the CHUCK Wagon provided a dual purpose. Initially, they served as extra counter space during food preparation. Later, they were used for serving. One advantage the MKT has, is extra counter space and floor space for cooks to move around. Measures are being taken to provide or free up additional working and serving surfaces aboard the CHUCK Wagon.

5.4 Safety/Health

5.4.1 Fire

The fact there is no open flame aboard the CHUCK, and inherently moderated surface temperatures means there is no chance for a grease fire. The MKT has not one, but *six* open flames on board, in the same area as the cooks. To make matters worse, the MKT grease collection bin is prone to spillage, and, is sandwiched directly between two of the hot, open-flame burners. Furthermore, fuel supply for the CHUCK is completely outside the kitchen whereas with either MKT configuration, fuel is contained in tanks in the burners themselves.

5.4.2 General Operation

The times injuries are most likely to happen are when heavy objects are being lifted, or when cooks are working more than a few feet off the ground. The heaviest objects a CHUCK Wagon cook need lift are the flooring sections which are almost manageable by one person. When on the flooring sections, cooks are only a few inches off the ground.

As described in the section on MKT setup, the very heavy floor sections hinge at the trailer sides and must be lowered. This subjects cooks to the danger of being clonked if there is a slip while the section is lowered.

Once the MKT flooring is set up, cooks must then move about a platform three feet off the ground as they set up equipment. Besides an accidental fall from the platform, setup of the heavy stair sections and having to lower them from the platform constitutes additional peril.

5.4.3 Air Quality

Combustion gases from the MKT M2 or MBU burners directly contribute to pollution in the kitchen area. It is widely accepted that the venting of burner combustion products in the vicinity of people is unwise, and even in cases where ventilation is complete there remains a danger of cooks directly inhaling fumes leaking around the edges of appliances. The CHUCK burner vents its exhaust outside the cooking area altogether, and so avoids this hazard.

5.4.4 Sound Level

Sound level was measured for the three kitchens. Subjective/perceived sound intensity validates the measured values. In the MKT with M2 burners, the noise amounted to a 72 dB-A hiss. The MKT-I with MBUs emitted an 82 dB-A growl. It is anticipated noise from the six MBU burners could, over time, cause the cooks stress and hearing damage. An additional operational safety concern is miscommunication; at this volume, it was difficult to hear clearly and participants felt the need to shout. The CHUCK Wagon was at a 72 dB-A rumble; conversation was easy, and the sound was tolerable for long periods of time.

5.4.5 Temperature

It is recommended that suitability of the CHUCK in other than fair weather conditions be evaluated. It appears that when the exhaust fan is on, despite the ground skirt, cold air will be drawn underneath the trailer chilling the cook's lower body. Temperature stratification was an issue with the MKT, even though it does not have an exhaust hood; this prompted addition of an warm-air circulation system for the MKT-I. In hot weather, however, the CHUCK Wagon exhaust fan will provide for *more* comfortable temperatures, an advantage because excessive heat within the MKT has always been an issue leading to heat stroke or dehydration of personnel.

5.5 Energy Consumption

Changing the MKT burners from gasoline-fired M2s to JP8-fired MBUs increased consumption by 64% (from 2.5 gal, to 4.1 gal) for this test. This increase was primarily due to the generator needed to power the JP8 burners. The CHUCK Wagon also requires electricity generation, but fuel consumption compared to the MKT-I was 22% less (3.2 gal to 4.1 gal).

The initial objective of the CHUCK was to reduce fuel consumption by 50%. Additional testing under controlled conditions will show why savings was not as great as expected. A partial explanation for this, is that the CHUCK Wagon becomes more efficient as demand for heat increases. So, it is anticipated that during meals involving heating large quantities of food in kettles, such as the rethermalizing of preprepared foods, the 50% objective would be realized. Steps can be taken to better insulate components that loose heat, and plan meals so appliances are used simultaneously rather than sequentially; this would have the added benefit of reducing preparation times.

Yet, even as the CHUCK Wagon operates at greater efficiency, it also produces more heat than either MKT. This greater heat output translates into an ability to cook more meals, faster than either MKT. The CHUCK uses a single 250 kBTU/hour burner; 65% of this heat (162 kBTU/hr) is available to appliances. The MKT operating at full capacity is capable of a net heat production of 90 kBTU/hr, and the MKT-I is capable of delivering 114.5 kBTU/hr to appliances. And even at full capacity, the efficiency of either MKT will remain below 30%.

5.6 Final Comments

Results of this testing might be slightly more representative of actual conditions if performed in true field-feeding situations, utilizing a full cadre of experienced food service personnel, with very limited interaction by NSC project officers. In all fairness, however, the three exercises were conducted as consistently as possible and with similar handicaps in the form of inexperienced personnel. And in the field, inexperienced KPs are used at almost every meal.

If the kitchens had been compared with sanitation center accompaniment, differences in the number of items washed, and sanitation difficulties due to differences in burnt food, would show

in the results. Furthermore, size of items taken to the sanitation center (i.e., the MKT griddle) varies significantly.

While there remain some issues to be answered regarding the CHUCK system, it is still considered developmental equipment and is constantly being improved to resolve any issues this or subsequent testing might unearth.

The exercise was sufficient to provide us with enough information to evaluate the CHUCK against the current field-feeding kitchens. The merits of the CHUCK Wagon were successfully demonstrated by this mock field-feeding exercise. As was found, it is certainly an improvement over current field-feeding systems.

This demonstration proved the CHUCK Wagon can be used to prepare A-ration meals for 250 troops with all food turning out satisfactorily and with ease. Most performance variables were found to be equal or better than either MKT configuration. Additional performance data will be needed to fully map out the performance in advance of the next prototype.

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Appendix A Demonstration of the MKT with M2 burners [27 September, 1999]

A-1 Timed Tasks

Table A-1 contains an overview of how long it takes to perform specific tasks while preparing a meal aboard the MKT. More details are presented and tasks are described and illustrated individually in the following sections.

Table A-1 MKT w/M2 Timed Tasks Overview

Task	# people	Time		Duration (minutes)	Comments
		Start	End		
Overall Time	2 – 6	9:05	2:20	315	5 working with 1 supervisor
Open and level	1 – 6	9:05	10:31	86	KPs provided additional help. Tools used – jack handles, tent side poles & vent crank.
Fuel filling	2	9:20	9:48	28	1 person is typical; wearing gloves; bring fire extinguisher to filling site; some fuel leakage from excess around fill cap; Tools used – tool box with wrenches & funnel.
Preheating burners	1-2	9:44	9:56	12	Tools used – tool box with wrenches, matches, preheater cover & pump.
Organize cooking area	2-4	9:17	9:38	21	Used a Vent crank
Meal preparation	2-4	9:39	12:36	177	Started serving before meal preparation was complete
Serving	2-3	11:34	12:06	n/av	115 served – if 250, time might be approx. 70 minutes
Clean up	n/av	12:03	1:25	82	
Packup	n/av	1:25	2:20	55	

A-1.1 Open and level

The MKT was set up on level, rocky ground. The tasks associated with opening, leveling, and organizing the cooking area and meal preparation overlap since there are several people participating. **Table A-2** outlines the steps that were taken to open, level and prepare the MKT for use. The bulleted comments and illustrations contain highlights specific to this test situation.

- One stabilizer was already unpinned from the underside of the trailer as shown in **Figure A-1**. One foot was stuck and WD-40 had been sprayed on it about an hour previous to the start of the test. One stabilizer was missing a foot completely. Other than that, the deployment of the stabilizers was close to representative of how it would go in the field. It should be noted that if the ground were muddy then deployment of the stabilizers would make the cooks very messy as can be seen in **Figure A-2** and **Figure A-3**. Setup of the curtain walls and opening the roof vents can be seen in **Figure A-4** and **Figure A-5**.

Table A-2 Specific Tasks Associated with Opening and Leveling the MKT

Task	# people	Time		Tools Required	Comments
		Start	End		
Lower stabilizers and feet	2-3	9:05	n/av	Jack handles, WD-40, Jacks are included	Missing foot
Roll up side panels and secure	1-3	9:08	n/av	n/ap	Remove elastic cords, roll up and secure with Velcro
Lower sides and end panels; add supports to secure all panels	4	n/av	9:16	n/ap	Someone on each side hold panels. Missing one corner panel support
Lift roof; visually level and secure	4	9:16	9:17	Without 4 people lift jacks are required.	
Remove support poles and steps and food and water containers; install steps	n/av	9:17	n/av	n/ap	Steps not level (added stones underneath steps to make more secure)
Remove M2 burners	2	9:22	n/av	n/ap	
Unroll floor mats, lift awnings and secure to support poles; add corner support poles;	2	9:28	9:50	n/ap	3 mats not used (1 serving line, 1 on each end)
Install screens	2	9:50	10:31	n/ap	Had to be redone because it was done incorrectly.
					3 screens not closed during food prep – each end of serving line and oven end of cooking area
Clean food prep area surfaces	1	9:36	9:39	n/ap	Cleaning of some containers was done
Open vents	1	Done during meal prep.	n/av	n/ap	Missing crank piece to open top vents – vents cranked by hand (cooks weren't tall enough)

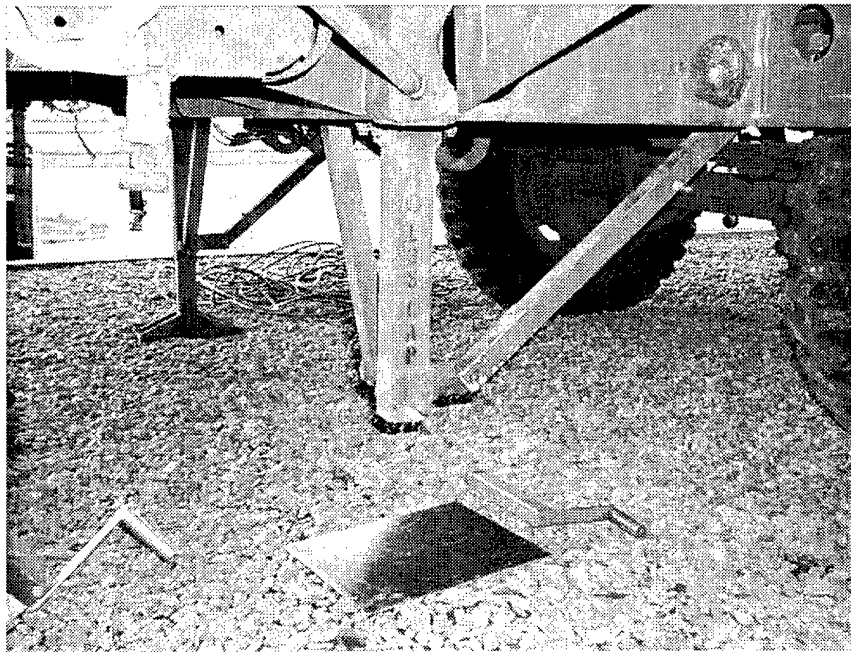


Figure A-1 Terrain Conditions and Missing Foot

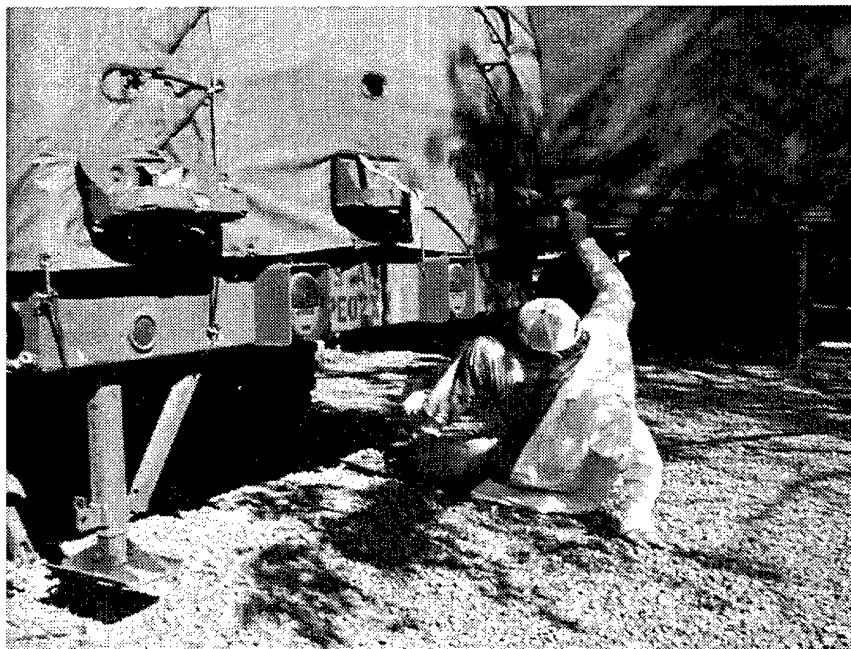


Figure A-2 Cook Kicking at Jack to Free It



Figure A-3 Removing Pins from Stabilizer

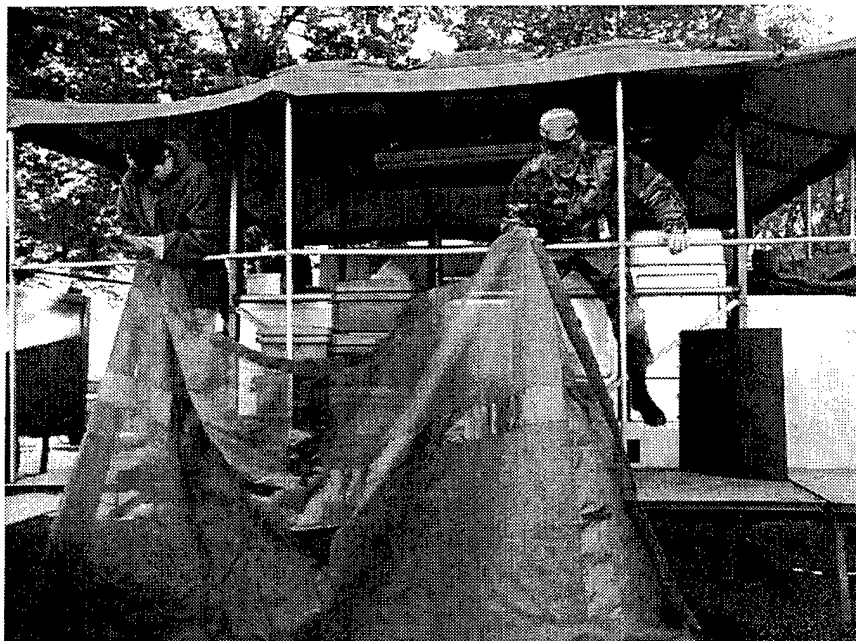


Figure A-4 Installing Sidewalls

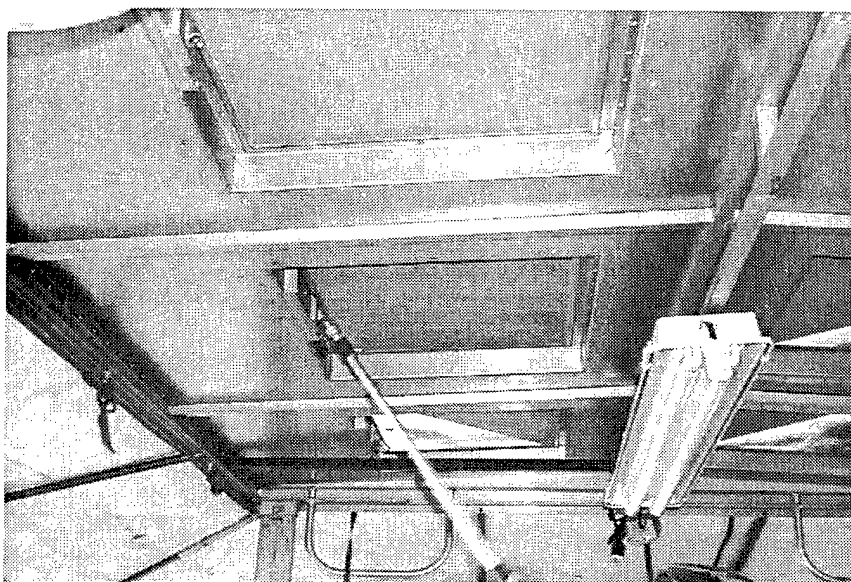


Figure A-5 Using Rod to Open Roof Vents

- Electrical power was not set up though often in field situation an extension cord is run to the trailer for a single overhead incandescent light.
- It should be noted that even though this kitchen facility is considered to be a self-contained environment which keeps cooks off the ground, there were a lot of items, including food and food containers, which were placed on the ground all around the trailer. This can be seen in **Figure A-6**. In the case of the food it was attempted that it be kept on tables and on a pallet.

A-1.2 Burners

A-1.2.1 Fueling

The first step was to bring fuel (gasoline) to the fueling area, which was approximately 50 feet (23 paces) from the MKT. Three 5-gallon jugs of fuel were used. As each burner was removed from its stowed position inside the MKT, they were brought to the fuel filling area, weighed, filled with gasoline and then weighed again (**Table A-3**). After being filled, each burner was then brought to lighting area, which was approximately 50 feet away from both the MKT and the fueling area.

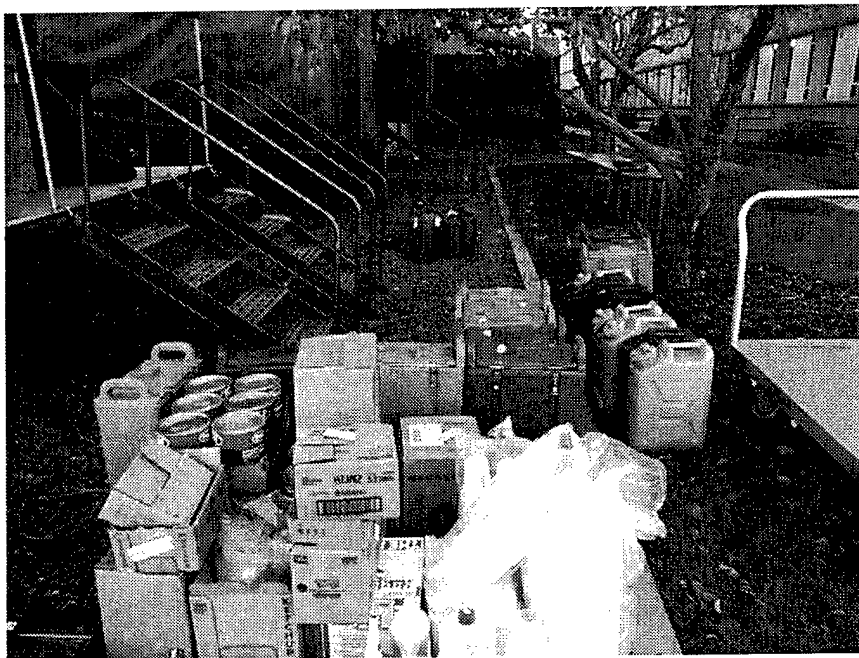


Figure A-6 Storage of Food Etc. Outside the Trailer

Table A-3 Initial M2 Burner Weight

ID #	Empty	Full
	(lbs)	
92-003	45	56.09
92-005	40	52.43
92-004	46	57.62
92-006	48	52.96
92-002	45	56.5
92-001	45	55.67

Note: The burners will be referred to by the last three digits in their identification number from hereon out.

A-1.2.2 Preheat

To preheat burners, the shields need to be removed from the bottom first. A pump is used to pressurize to 6-8psi and light (pump provided). It is important to keep an eye on pressure (need to keep psi below 10psi).

The burner is lit (**Figure A-7**) and when a blue flame appears, two people move the burners to the MKT (**Figure A-8**) and insert them into appliances (**Figure A-9**) The preparation time and the appliances where the burners were placed are shown in **Table A-4** and **Table A-5**.

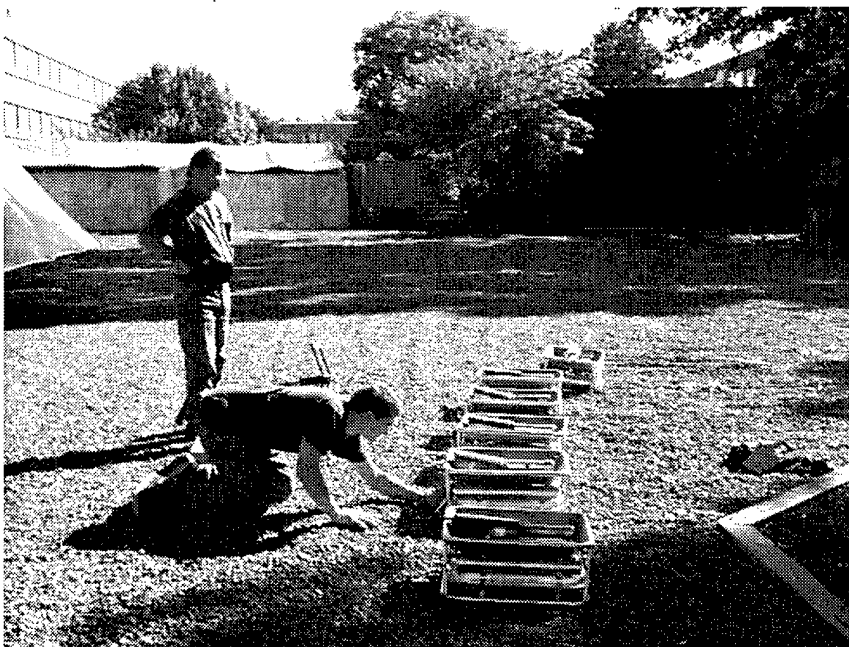


Figure A-7 Lighting Burners



Figure A-8 Carrying Lit Burner to MKT

Table A-4 M2 Burner Preparation Time

ID #	Time			Comments
	Start Pump	Preheat	Light	
-003	9:44	9:46	10:15	1 st burner – being fussy
-005	9:49	9:50	10:12	Trying to light with match
-002	9:50	9:51	10:05	
-004	9:51	9:53	10:17	
-006	9:54	9:55	n/av	Hold back for griddle until needed
-001	9:55	9:56	n/av	Hold back for griddle until needed
-006	n/av	10:40	10:54	Needed to be preheated again since it was waiting to be used
-001	n/av	10:41	11:02	Needed to be preheated again since it was waiting to be used
-005	n/av	11:00	11:07	Moved under left griddle

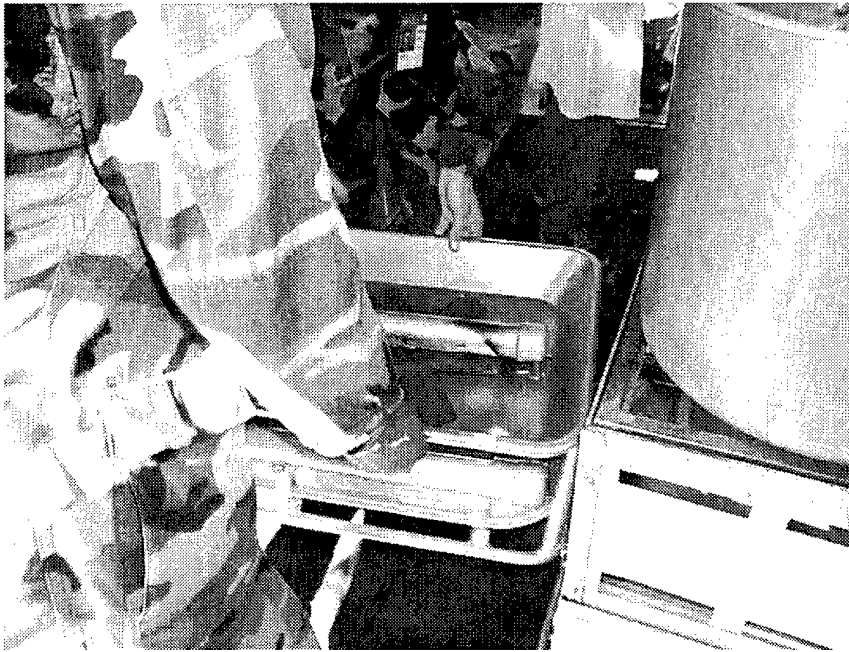


Figure A-9 Inserting Lit Burner into Appliance

Table A-5 M2 Burner Location

Burner	Location	Time Moved
-001	Right griddle	11:03
-002	To Right M59 range	10:08
-003	Under Left cooktop	10:16
-004	Under Right cooktop	10:19
-005	To Left M59 range	10:14
-006	Replaced -005 in Left M59	10:54
-005	Left griddle	11:08

A-1.3 Organize cooking area

There was insufficient data available to present a table for this section. Organization of the area began at 9:20.

A-1.4 Meal Preparation

- During the meal preparation, a spatula, slotted spoons, and hot pads were needed, yet were not available in the MKT. The spatula and slotted spoons are included in field manuals, the hot pads are not.
- Griddle dimensions are 42"W x 24D" x 36"H. Cooking burgers on the griddle is illustrated in **Figure A-10**
- The grease funnel assembly was not used on the griddle this time but the collector was. A crushed pop can had to be placed between the grease collector and the burner so that the grease would not spill. The collector assembly is shown in **Figure A-11**.
- Counter is 17"W x 23D"
- Counter space tight during early preparation.
- These tasks are not necessarily done in this order every time.
- The pan on top R oven buckled (turned down temp on burner). Oven out of level, spilled batter on oven on one pan. Cooking of cakes is illustrated in **Figure A-12** and **Figure A-13**
- Latch holds open top of M59 – needs to be manually released (with mitts) to close top
- 10:52 L M59 burner out – removed, checking for leaks. Leaking fuel from front, maybe a leaky gasket. Used wrench to tighten bolt that spindle knob 10:55 Replaced burner with
- the collector would stay pushed far enough to catch runoff.

A summary of times required to perform meal preparation tasks is shown in **Table A-6**.

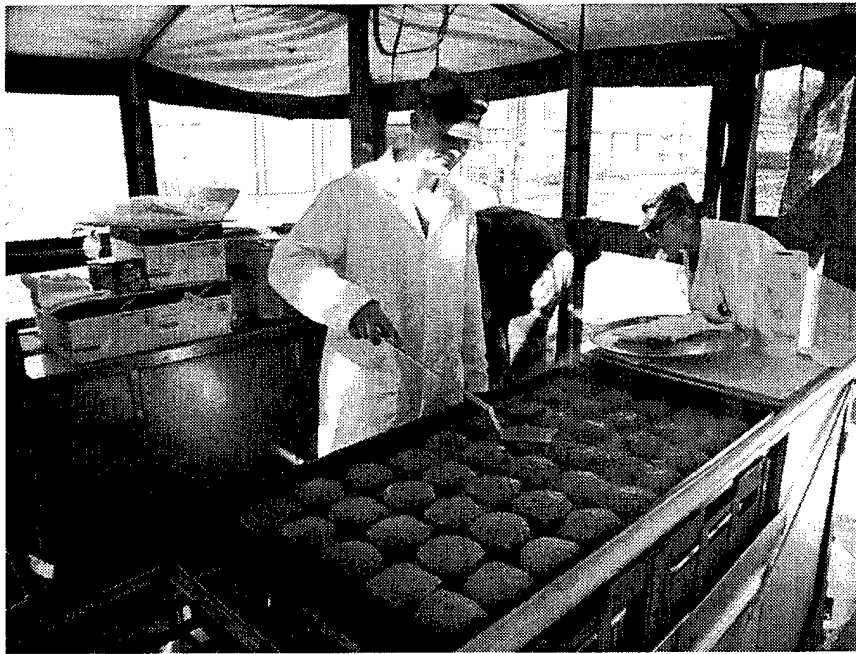


Figure A-10 Frying Burgers



Figure A-11 Grease Collection Container

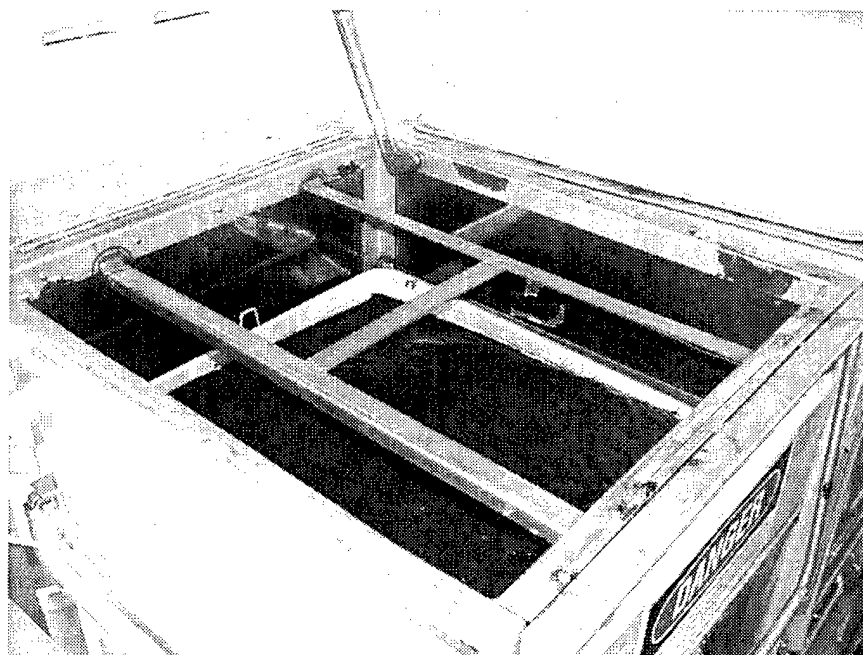


Figure A-12 Location of Cake in M59 Range



Figure A-13 Checking on Cake in M59 Range

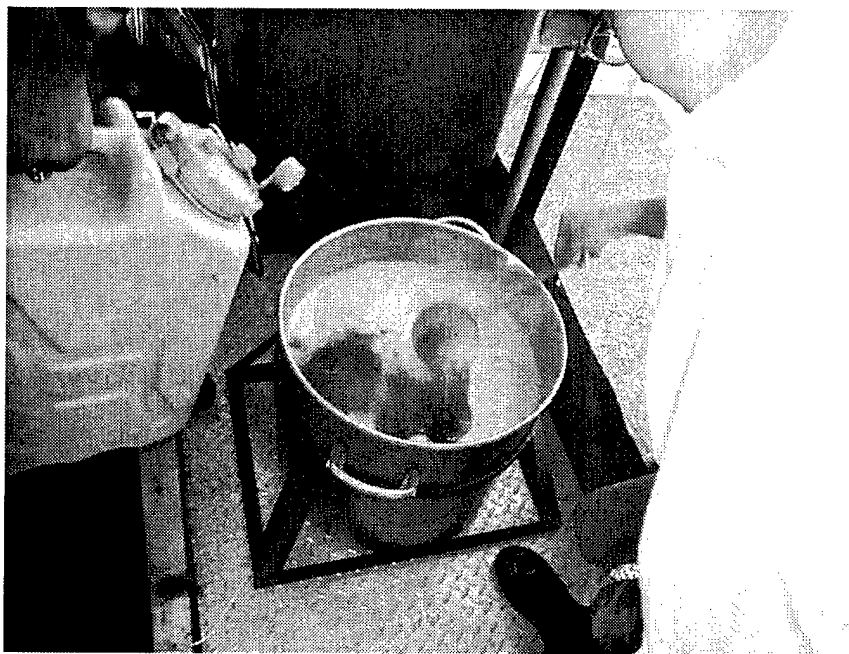


Figure A-14 Making Coffee

Table A-6 MKT Meal Preparation Task Time

Task	# people	Time		Tools Required	Comments
		Start	End		
Prep 2 ½ boxes (5 lb) cake	1	9:39	n/av	10 gal pot, spoon	
Shred lettuce	1	n/av	n/av	n/ap	
Open 12 #10 cans of beans	1	n/av	n/av	Can opener	Difficulty opening cans – getting first puncture
Put beans in squarehead pan	1	n/av	n/av	n/ap	
Fill 15 gal pot and 10 gal pot	2	n/av	n/av	n/ap	coffee and hot water for drinking
Grease pans and fill	1	n/av	10:23	Too few sheet pans – have 4, need 6	
Put cakes in ovens	1	10:23	10:27	n/ap	1st in LM59 bottom 10:23
					2nd in RM59 bottom 10:26
					3rd in RM59 top 10:26
					4th in LM59 top 10:27
Clean prep counter	1	10:28	n/av	n/ap	
Rotate cakes top/bottom*	1	10:38, 10:40		n/ap	Within same oven
Checked cakes	1	10:44, 10:50, 10:55		n/ap	
Washed pot from cake	1	n/av	10:45	n/ap	
Open 12 #10 cans of corn	1	n/av	n/av	n/ap	
Put corn in 15 gal pot	1	n/av	n/av	n/ap	
Dispose of cans and liquid in trash bags	1	10:44	n/av	n/ap	
Open #10 cans of peaches	1	10:46	n/av	n/ap	
Fill 3 5-gal cans with water from hose	2	10:46	n/av	n/ap	
Put beans on top of L M59	1	10:57	n/av	n/ap	"new" squareheads don't fit under M59 cover. Have to put hand under pan and tip to close lid (took 2 people). Couldn't tilt pan enough – used lid on squarehead instead
Cut cake	1	10:59	n/av	n/ap	54 pieces x 4 sheets = 216 pieces
Fill Cambro beverages	2	11:04	n/av	n/ap	hot water for drinking, filled another with ½ hot, ½ cold for hand washing
Put corn on burner	2	11:05	n/av	n/ap	start at 68 deg
Put beans on top of R M59	1	11:06	n/av	n/ap	
Remove cakes from R M59	1	11:07	n/av	n/ap	place cake in baker's rack
Make coffee	2	11:10	n/av	supporting 15 gal pot in cradle from M59	start with hot water, add coffee, let seep, add some cold water
Adjust temp of burner under corn	1	11:11	n/av	n/ap	
Cook burgers	2	11:12	12:36	n/ap	45 per griddle (5 x 9) – 3 boxes of 80 each total ~ 15 min per batch
Put beans in Cambro	1	11:28	n/av	n/ap	

A-1.4.1 Equipment Temperatures

Table A-7 MKT Equipment Temperatures

Location	Temperature	Time
	(°F)	
Top of L M59	370	10:23
Bottom of L M59	505	10:23
Top of L M59	410	10:37
Bottom of L M59	540	10:38
Top of R M59	280	10:40
Bottom of R M59	430	10:40
R griddle	259	11:20
L griddle	227	11:20
griddle	250	11:27

A-1.4.2 Food Temperatures

Table A-8 MKT Food Temperatures

Item/Location	Temperature	Time	Comment
	(°F)		
Water on R cooktop	90	10:36	approx. 8 gal
Water on L cooktop	96	10:36	approx. 10-12 gal
Water on L cooktop	160	11:03	
Water on R cooktop	176	11:06	
Hamburger on plate	132	After 2 min	
Corn on plate	100	After 2 min	
Beans on plate	107	After 2 min	

A-1.5 Serving

As part of the serving process, the cooks set up a hand wash station using a mixture of heated water and cold water. The serving process was a “straight line feed” (**Figure A-15** and **Figure A-16**) to allow for the fact that one MKT corner floor panel was unsupported. The beans were served from a Cambro placed on the cooktop, as were the hamburgers (**Figure A-17**).

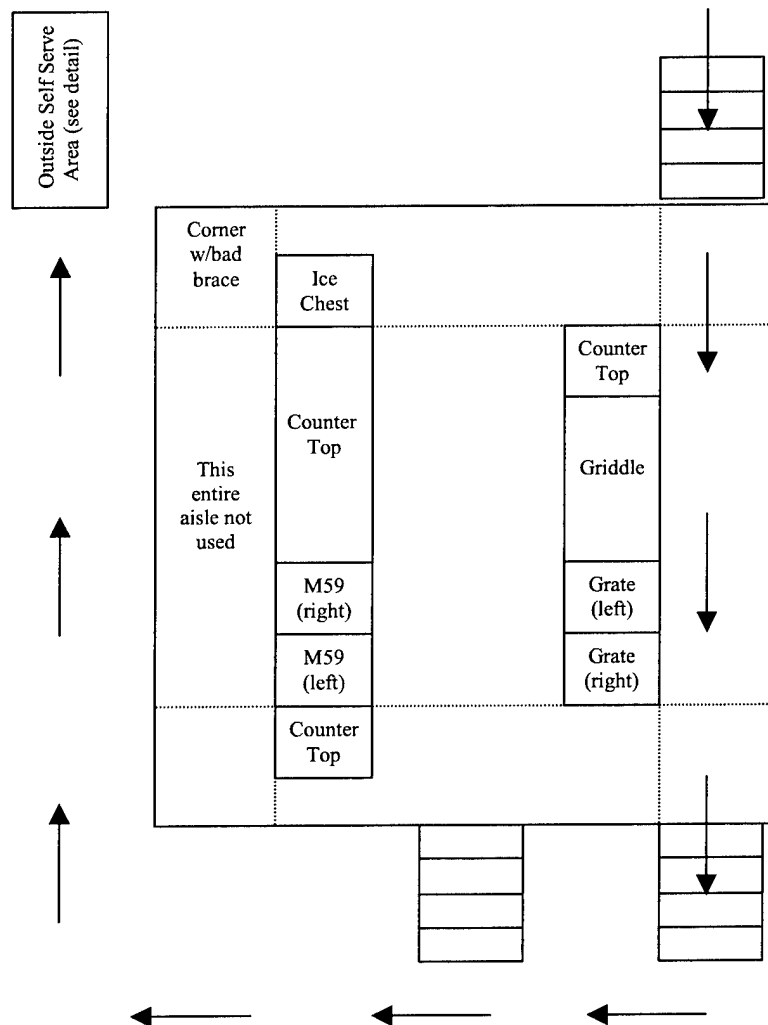


Figure A-15 MKT Layout and Hot Food Serving Line

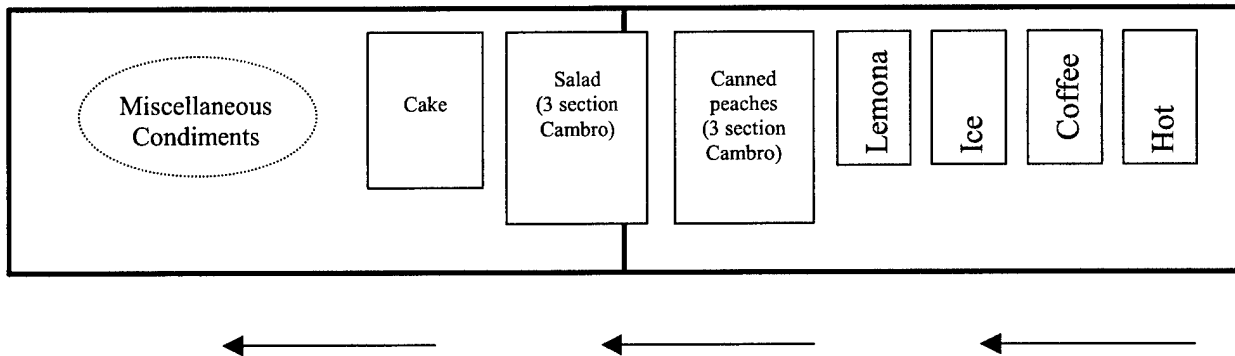


Figure A-16 Detail of MKT Self Serve Area

- When serving began, four of the M2 burners were turned off. The remaining two, under the griddle, were left on until all of the hamburgers were cooked. Serving began before all of the hamburgers were cooked. A typical serving = 1 spoon each of beans, corn and 1 burger (sometimes 2 burgers). A total of 116 people were served. Even though there was enough food available for up to 240 people, only 116 servings were provided due to lack of consumers. The last person was served at 12:06. All leftover beans, burgers, and corn put in Cambro containers on outside serving tables. Before the transfer began, the skimmer was rinsed, and new Cambros (not serving ones) were used.
- At 12:41 the remaining two M2 burners under griddle were turned off.
- The condiments included were: hot sauce, relish, mustard, ketchup, coffee and non-dairy creamer. The layout is shown in **Figure A-18**.
- The two tables used for the self serve area were provided by the Natick Soldier Center and are not included as part of the MKT inventory



Figure A-17 Staging of Cooked Burgers in Cambro



Figure A-18 Layout of Condiments and Cake

A-1.6 Clean up

- These tasks are not necessarily done in this order every time. The “sanitation center” was an NSC building for this demonstration.
- Grease splattered on rail and mats in front of serving line. Splatter guards are typically used if serving while cooking (not planned for this demonstration).
- The hose to dispense water was pressurized. Generally they would not have pressurized water in the field and so it may be more labor intensive to rinse things all the time with water sloshed from 5 gallon jugs.

Itemized times for cleanup tasks can be found in **Table A-9**.

Table A-9 MKT Cleanup times

Task	# people	Time		Tools Required	Comments
		Start	End		
Poured out corn liquid	2	12:48	n/av	n/ap	In "sanitation center" (60 lbs, although 4 cans of liquid were not in pot)
Removed trash	1	n/av	n/av	n/ap	
Emptied coffee from pot	2	n/av	n/av	n/ap	In "sanitation center"
Removed burners under griddle	n/av	12:53	n/av	n/ap	lots of grease had spilled under L cooktop burner from griddle
Remove grill tops and "doghouses"	n/av	n/av	n/av	n/ap	on ground outside MKT waiting for cleaning
Remove griddle	2	n/av	n/av	n/ap	
Place 2 squareheads, Cambros, griddle on cart	n/av	n/av	n/av	n/ap	to "sanitation center" for cleaning
Empty grease collection tray	n/av	n/av	n/av	n/ap	in "sanitation center" (4lbs)
Clean grease off cabinets	n/av	n/av	n/av	paper towels (approx ½ roll)	most labor intensive part of cleanup
Sprayed all surfaces	n/av	n/av	n/av	Fantastik and paper towels	
Stored cradle in M59	n/av	n/av	n/av	n/ap	
Dump water from 5 gal cans	n/av	1:18	n/av	n/ap	
Waiting for items in "sanitation center"	n/av	1:19	1:46	n/ap	

A-1.7 Packup

- There was a wait of approximately four minutes while waiting for items in "sanitation center".
- The two tables went back inside, rather than being packed up with the MKT because it was determined prior to pack up that those particular tables, being too long, would not fit.
- The left over food not used in preparing the meal went with Frank. This also included things like the spices, cleaners etc. in the field those things may have remained on the MKT, or they may have gone "in the truck".

Table A-10 MKT Pickup Times

Task	# people	Time		Tools Required	Comments
		Start	End		
Replace "doghouses", M2s and grill tops	3	1:25	1:27	n/ap	
Remove screens and fold	n/av	1:27	1:35	n/ap	
Stow screens	1	1:35	1:38	n/ap	
Remove railings and posts (except corners)	n/av	n/av	n/av	n/ap	
Close vents	n/av	1:34	n/av	n/ap	
Stow pots	n/av	1:37	n/av	n/ap	
Replace griddle – reassemble beverage Cambros (12) and pots	n/av	1:46	1:52	n/ap	
Stow stairs	n/av	1:53	1:56	n/ap	confusion on how stairs were stowed because one set of stairs was 5 steps instead of the usual 4
Store cambros, railings, posts*	n/av	1:56	2:08	n/ap	trying to reconfigure everything to fit into middle of MKT, different stairs made process difficult
Lower side panels	n/av	2:09	2:10	n/ap	
Lower roof	n/av	2:10	2:11	n/ap	
Lift end floor/ramps	(2 per end)	2:11	2:13	n/ap	
Lift side floor/ramps	n/av	2:13	2:16	n/ap	
Secure side panels	n/av	2:16	2:19	n/ap	
Lower jacks, pull up legs	n/av	2:16	2:20	Jack Handles	One of the legs wasn't working right and was only cranked up so it was off the ground; and the lashing wasn't perfect

A-2 Environmental Measurements

A-2.1 Illumination levels

Table A-11 MKT Light Levels

Location		Light Level	Time taken
Desc.	Height	(fc)	
Center of MKT	approx 45" off floor	45	n/av
Outside in sun	Horiz surface	410	9:30
Over griddle	Chest height	50	11:28
Outside in sun	Horiz surface	680	11:57
In front of R-M59	n/av	50	11:57

A-2.2 Sound Levels

Table A-12 MKT Sound Level

Location		Noise level	Time	Comments
Desc.	Height	(dB-A)		
Center of MKT	approx. 56" off floor	72	n/av	4 burners and talking
Outside MKT@ approx. 6 ft from M59 corner	n/av	68	11:33	

A-2.3 Ambient Air Quality and Burner Emissions

- Orange monitor put in MKT next to L M59 @ 11:32
- Griddle smoke low – dissipates quickly, none in anyone's face/no wind
- Started Bruel-Kjar @ 10:48 (measures formaldehyde, SO₂, CO₂, CO) Sensor hanging on overhead light (repositioned at 10:54) (Internal time started at 9:53 ended 11:19 – approx 12:30 by our watches)
- Exhaust gas analyzer internal clock is 4 min off from our watches

Table A-13 M2 Burner Emissions

Appliance		Time	Efficiency	CO2	Excess Air	Amb Temp
			(%)	(%)	(%)	(°F)
Griddle		11:27	36.9	2.6	401	76.2
M59	(right)	11:14	n/av	0.7	1871	70.7
M59	(left)	11:12	26.3	0.6	2196	69.9
Cooktop	(right)	11:07	40.4	3.5	268	68.3

Table A-14 MKT Ambient Air Quality

Gas	Measurement	Height	Time taken	Comments
CO	9ppm	65"	10:34	Measurement taken between burners
SO ₂	3.17	n/av	11:20	

A-2.4 Ambient Temperatures

- Clear, dry conditions

Table A-15 M2 Ambient Temperatures

Location		Temperature	Time	Vents open/closed
Desc.	Height	(°F)		
Outside MKT	In sun	71	9:30	N/A
Outside MKT	In shade	65	9:30	N/A
@ center of MKT	65 in. above floor	84	10:34	closed
outer edge/aisle away from ovens	65 in. above floor	74	10:34	closed
center of MKT	50 in. above floor	73	10:41	open
outside MKT	in shade	65	10:41	N/A
outside MKT	in sun	73	10:41	N/A
center of MKT	65 in. above floor	72	10:43	open
outer edge/aisle away from ovens	65 in. above floor	70°F	10:43	open
serving line behind cooktops	(burner level?)	110°F	11:05	open
@ center of MKT	65 in. above floor	82°F	11:06	open
outer edge/aisle away from ovens	65 in. above floor	72°F	11:06	open
@ center of MKT	52 in. above floor	72°F	12:16	open
@ outer edge/aisle away from ovens	52 in. above floor	72°F	12:16	open
approx 3 in. in front of burner	20 in. above floor	86°F	12:16	open

A-3 Consumed Resources

A-3.1 Fuel Consumption

As each burner was removed from the MKT, it was weighed, emptied of fuel, and then weighed again. The weights of the burners, when removed from the MKT have been increased by .6 pounds to account for the weight of burner shields which were removed from each burner prior to installing into the MKT for cooking. These burner shields were attached to the burners when the initial weights were taken at the beginning of the demonstration.

Table A-16 Fuel Can Weights

Can	Initial	After Filling Burners	After Emptying Burners
	(lbs)		
Metal #1	34.5	29.6	29.57
Metal #2	38.75	10.16	30.47
Plastic	38.5	6.04	39.01

The weights of the gasoline containers used to hold the fuel are presented above. The containers were weighed at the start of the demonstration prior to any filling of burners. Once the burners were filled, the containers were weighed again. Finally, at the conclusion of cooking, as the

Table A-17 M2 Burner Weights

ID #	Initial Empty	After Filling	After Cooking	After Emptying
	(lbs)			
-001	45	55.67	$50.71 + .6 = 51.31$	$43.64 + .6 = 44.24$
-002	45	56.5	$52.84 + .6 = 53.44$	$43.63 + .6 = 44.23$
-003	45	56.09	$52.60 + .6 = 53.20$	$45.55 + .6 = 46.15$
-004	46	57.62	$53.66 + .6 = 54.26$	$44.73 + .6 = 45.33$
-005	40	52.43	$47.31 + .6 = 47.91$	$38.86 + .6 = 39.46$
-006	48	52.96	$50.85 + .6 = 51.45$	$39.31 + .6 = 39.91$

burners were removed from the MKT, the fuel remaining in them was emptied back into the containers and those containers were weighed one more time. From the data in the preceding table, it appears that all of the burners were not completely empty at the start of the exercise.

The most straightforward method of calculating fuel used is to take the difference between the fuel can weights before and after the test. This gives us 12.6 lbs. However, subtracting burner weights gives 16.3 lbs. If we average these, and use a density of 5.8 lbs/gallon, the meal consumed 2.5 gallons.

A-3.2 Trash

Table A-18 Trash Weight

Content Description	Weight
	(lbs)
Mostly cans	16.3
Mostly wet stuff	16.5
Paper products	3.85
Paper products	5.28
Paper products	2.91
Paper products	10.57
Boxes	16.41
Total	71.82

A-3.3 Demographics

Table A-19 MKT Demographics

#	Role	Sex	Ht	MOS	Yr in MOS	Clothing	Name
1	Supervisor	F	64"	92G	9Y	BDU w/overcoat	SGT Powell
2	Cook	M	69"	92G	3	BDU w/overcoat	SPC Villar
3	Cook	M	73"	CIV	-	Civ w/overcoat	Chad Haering
4	Cook	M	70"	CIV	-	Civ w/overcoat	Frank DiLeo
5	Cook	M		CIV	-	Civ w/overcoat	Alan Labrode

Appendix B - Demonstration of the MKT-I with MBU Burners [October 19, 1999]

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Appendix B Demonstration of the MKT-I with MBU Burners [October 19, 1999]

B-1 Timed Tasks

An overview of the timed tasks is presented in **Table B-1**. More details are found in the subsections.

Table B-1 Timed Tasks Overview

Task	# people	Time		Duration	Comments
		Start	End		
		hh:mm		minutes	
Overall Time	n/av	8:40	1:41	301	
Open and level	5	8:40	9:20	40	
Fuel filling	1	9:22	10:16	54	
Lighting burners	n/av	9:44	10:19	35	
Organize cooking area	n/av	8:49	9:25	36	
Meal preparation & cooking	3	9:25	11:45	140	1 set up serving table/drinks
Serving	2	11:20	12:05	45	
Clean up	4	12:11	1:15	64	
Strike and pack up	n/av	12:40	1:41	61	

B-1.1 Open and level

The open, level, and organize tasks overlap. In other words, once the MKT-I is opened enough to get inside, the organizing starts – some people continue with the set-up tasks, while others start pulling items out of the MKT-I. Five people participated in this task.

Procedures are as follows:

- Unlatch and open side walls
- Let down legs
- Roll up side walls (Note: Villar and Frank could not attach the side walls at roof – they were just a bit too short, one of the other guys had to clip them up)
- Use cranks to stabilize legs
- Pull down walkways – took 3 people together to do this
- Adjust corners/stabilizers at corners
- Lift ceiling – took 4 people together (one at each corner) to lift (**Figure B-1**)
- Poles hooked up for ceilings/wall fabric

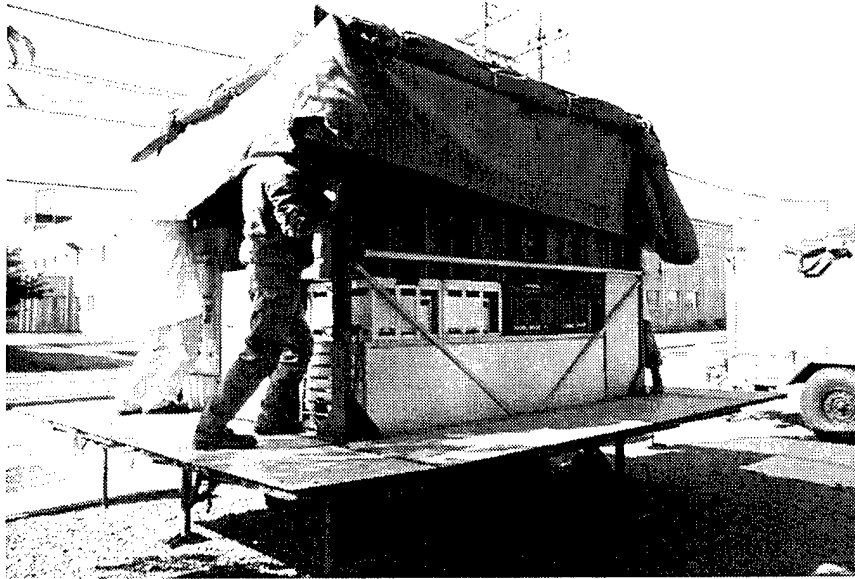


Figure B-1 Lifting MKT Roof from Transport Position

- Hook on stairs
- Place shield around griddle
- Attach screens

B-1.2 Burners

B-1.2.1 Fueling

The burners were weighed empty before they were placed in their positions within the MKT-I. They were then filled in place with cans of JP-8 fuel, removed and re-weighed full. At the end of the cooking, the burners were removed and weighed again, the remaining fuel was emptied into the 3 cans and the burners were weighed again. More details related to fuel consumption are contained in section **B-3.2 Fuel Weight**

Total time to fuel all burners was 54 minutes. The entire fueling process could take as little as 20 minutes if no errors are encountered as is evidenced in the data shown by **Table B-2**. However, the filling mechanism used created issues that added to the total time. Although

Table B-2 Time Required to Fill Burners

Burner Reference ID#	Time		Duration
	Start	End	
	hh:mm		Minutes
-21	9:22	9:26	0:04
-3	9:44	9:46	0:02
-23	9:55	9:59	0:04
-19	10:00	10:02	0:02
-11	10:10	10:13	0:03
-18	10:14	10:16	0:02

three filler assemblies were available for connecting MBU's to gas cans, only one worked, so only one burner could be fueled at a time . Filling of the burners is illustrated in **Figure B-2**. Several times during the fueling process error "4" was displayed, indicating that the burner had not filled in the allocated four-minute limit. This error occurred because the burner's suction pump could not pull fuel well enough through the hose once the fuel can had only 1-1.5 gallons left. There was also trouble fueling because of the long hose length.

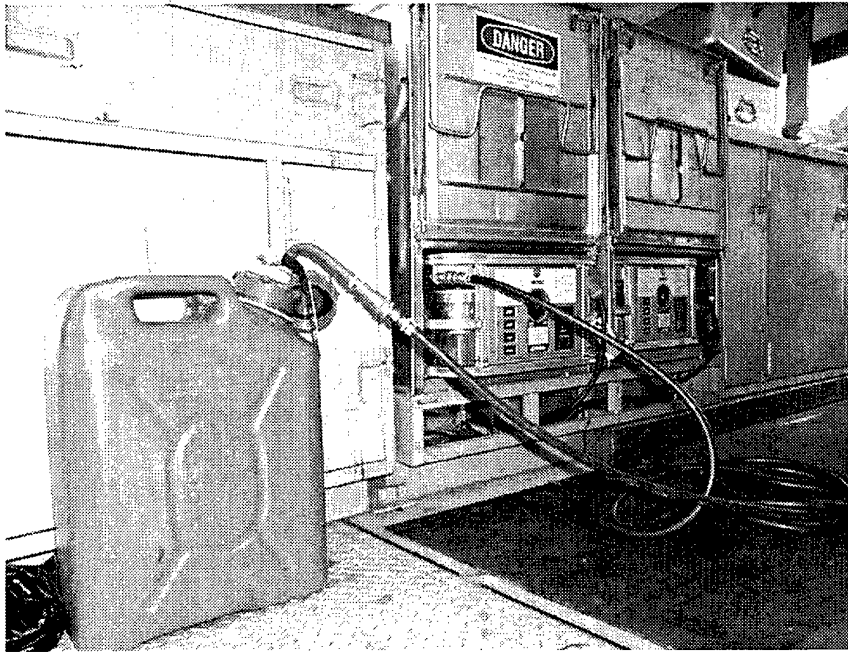


Figure B-2 Fuel Can in Position to Fill MBU

B-1.2.2 Lighting

Lighting of the MBUs is quite simple. As long as the electrical power supply is on, all it takes is a push of a button.

B-1.3 Generator

The generator (**Figure B-3**) with a half tank of fuel weighed 145.48 lbs at the beginning of the test. During the course of the demonstration, 13.61 pounds of fuel was added to the generator. The final weight of the generator was 147.5 lbs. A total of 11.59 pounds of fuel were consumed by the generator.

Ordinarily generators are surrounded by sandbags on three sides to help dampen the sound generated. The open side would be faced toward the MKT-I rather than the camp perimeter. The cart used to take the generator out to the site was tipped on its side next to the generator to

simulate such an arrangement. Setting up and transport of sandbags or hay bails would introduce additional time and weight factors.

At 9:12 a.m. the generator was moved 25 paces (approximately 50 feet) away from the MKT-I. The power cord was hooked and a grounding rod was pounded into the ground right next to the generator.

At some point most of the way through the test, generator fuel level was checked and a small amount of fuel left over in one of the cans added to the tank. .

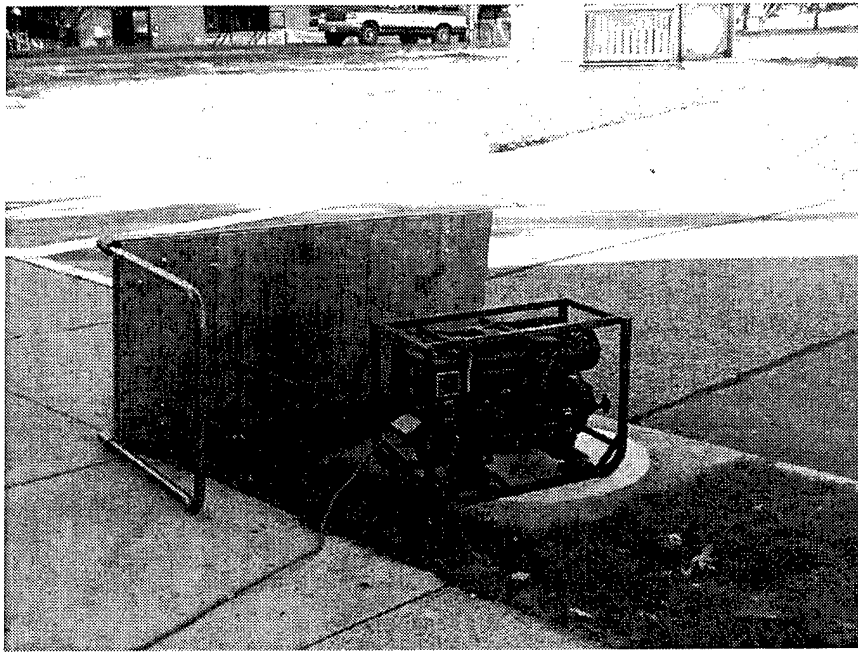


Figure B-3 Generator

B-1.4 Organize cooking area

A hose was used to rinse/wash various equipment including 4 5-gal water jugs, (3) Cambro w/insert.

At 9:21 the cooks started unloading contents of the MKT-I – i.e., the beverage containers, Cambros, tables, pots & utensils etc. and started setting up tables (drinks, cups, etc.) Additional items such as salt, pepper, hot pads, etc were provided by NSC personnel.

Fantastik® was used to clean food preparation surfaces.

B-1.5 Meal Preparation

A comprehensive list of tasks and some associated times can be found in **Table B-3**.

Table B-3 Timed Tasks for Meal Preparation

Task	# people	Time		Tools Required	Comments
		Start	End		
		hh:mm			
Mix 2 ½ boxes (5	n/av	9:25	9:35	n/ap	
Rinse then fill (4) 5-		9:28		n/ap	Two for water, one for lemonade
Open 12 #10 cans of	2	10:00	10:03	n/ap	
Put beans in squarehead pan	n/av	n/av	n/av	n/ap	
Fill 15 gal pot and 10		9:24		n/ap	
Grease pans		9:32	9:35	n/ap	
Fill cake pans		9:52	10:00	n/ap	
Put cakes in ovens		9:56	n/av	n/ap	
Clean prep counter		n/av	n/av	n/ap	
Rotate cakes		10:12	10:14	n/ap	Regular hot pads are not good
Wash Cambro		10:15	n/av	n/ap	
Washed pot from cake		n/av	n/av	n/ap	
Open 10 #10 cans of		9:37	9:45	n/ap	2 cans not opened (10 opened)
Put corn in 15 gal pot		n/av	n/av	n/ap	
Dispose of cans and		n/av	n/av	n/ap	
Fill 3 5-gal cans with		n/av	n/av	n/ap	
Put beans on top of		10:27	n/av	n/ap	
Cut cake		n/av	n/av	Knife	
Fill Cambro		n/av	n/av	n/ap	
Put corn on burner		10:09	n/av	n/ap	Left Kettle
Put beans on top of		10:31	n/av	n/ap	
Remove cakes from		10:23	10:42	n/ap	1 st at 10:23, 2 nd at 10:26, 3 rd at
Wash Cambro		10:25	n/av	n/ap	
Make coffee		10:45	n/av	n/ap	
Remove corn from		11:01	n/av	n/ap	
Cook burgers		10:30	11:45	Spatula	Each batch took 6 minutes
Put beans in Cambro		n/av	n/av	n/ap	

B-1.5.1 Cooking Temperatures

Food temperature data is contained in **Table B-4**. Burner power settings are shown in **Table B-6**, while the actual temperatures of appliances are in **Table B-5**. Some tasks are illustrated in **Figure B-4** and **Figure B-5**.

Table B-4 Food Temperatures

Item/Location	Temperature	Time taken	Comment
	(°F)	(hh:mm)	
Water on Right cooktop	59	9:59	Start temp
Water on Right cooktop	183	10:45	
Beans	50	10:10	Start temp
Beans on Left M59	190	11:00	Alex's thermometer
Beans on R M59	175	11:00	Alex's thermometer
Beans on Left M59	120	11:13	Alex's thermometer
Beans on Right M59	98	11:13	Alex's thermometer
Hamburger on plate	165	Fresh off grill	
Corn on cooktop	156	10:59	
Corn in Cambro	170	At serving	
Beans in Cambro	133	At serving	
Hamburger in Cambro	160	At serving	
Beans in 2 nd tray	130	n/av	
7.5 gallons of coffee in pot	155	At serving	

Table B-6 Burner Settings

Burner Reference ID#	Location	Power Setting	Time		Duration
			Lit	Turned Off	
			hh:mm		hh:mm
-21	R M59	25%	9:44	11:38	1:54
-3	L M59	25%	9:49/10:06	11:15	1:26
-23	R cooktop	100%	10:01	10:46	0:45
-19	L cooktop	100%	10:07	11:01	0:54
-11	R Griddle	100% to 50%	10:16	11:39	1:23
-18	L Griddle	100% to 50%	10:19	11:39	1:20

Table B-5 Appliance Temperatures

Location		Temperature	Time taken	Comments
		(°F)	(hh:mm)	
Left M59	Square-head	390	10:12	Alex's thermometer
	Inside	610	10:12	Alex's thermometer
Right M59	Square-head	330	10:12	Alex's thermometer
	Inside	360	10:12	Alex's thermometer
Griddle		396	10:39	Burners ½ on
		359	10:48	
		333	10:48	Added 32 frozen burgers
		311	10:56	Flipped 32 frozen burgers - Cook commented he could "definitely tell it was much colder now" referring to the griddle, after the temp dropped.

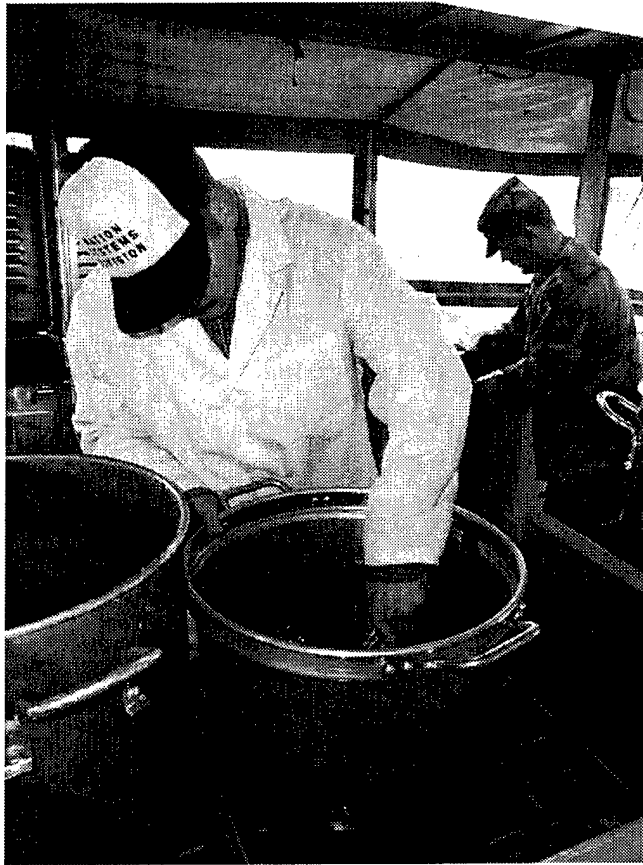


Figure B-4 Mixing Beans



Figure B-5 Filling IBCs for Beverages

B-1.5.2 M59 Range Cabinet

When the M59 range cabinet is packed up, the heat shields may be stored either under the square-head or just above the burner so there is enough room to store the pot cradle and pot. In this case, the heat shields were last stored just above the burner. When the trailer was unpacked, the pot was removed but the racks were forgotten; when the burner was ignited the 1/16 inch thick aluminum plate promptly melted onto the burner. After some wrestling with the hot twisted metal, it and the burner were extracted from the range. The piece that was directly on the burner is shown in **Figure B-6**, the other rack can be seen in **Figure B-7**. Once some aluminum slag was dumped out of the burner, it was returned to service with no problems. The M-2 doesn't melt the rack, but the MBU does. This is a major training issue with the MBU.

During the MKT-I test one banister was removed to make stairway access easier; the cooks could then step sideways onto the steps.

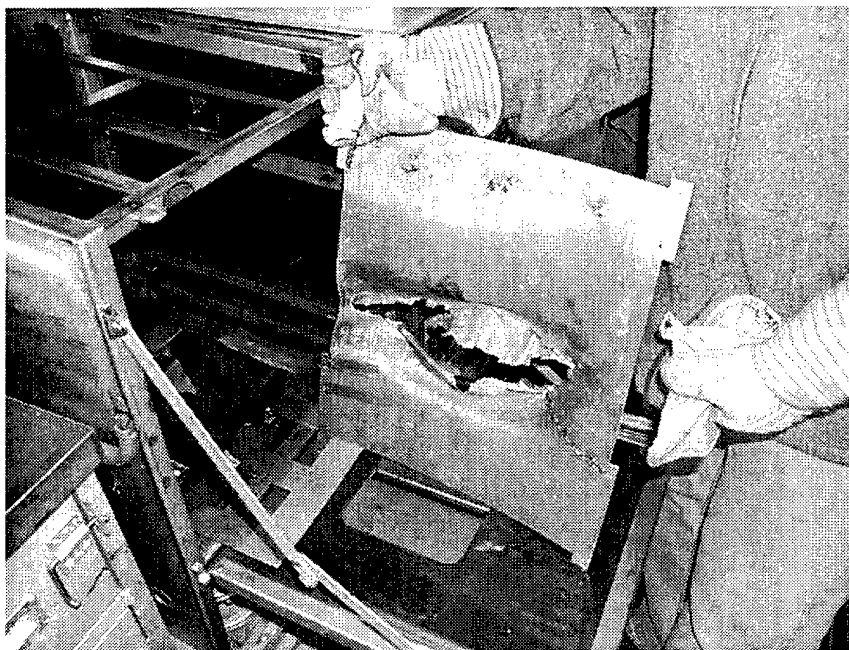


Figure B-6 Heat Shield Fresh from the Oven

B-1.5.3 Griddle

During the demonstration, the MKT-I wasn't level, so the cook had to slide grease off the griddle. It was not draining by itself. The griddle works okay but doesn't drain grease; this slowed down the meal preparation tasks.

Note: Grease trap still jury rigged as was in MKT w/M-2's to collect grease coming off of the griddle.



Figure B-7 Cooling Down Melted Heat Shields

Seem to be under-utilizing griddle, not really rushing and filling with burgers

There was lots of steam/smoke but not going in face

Comment from cook: "these burners (*MBUs*) are really hot" "Kick off more heat than M-2, but less fumes. The heat goes right out (*the roof vents*) so it's nice". "Much nicer than M-2"
 11:45: Discussion on whether we should turn the right kettle MBU back on to keep the baked beans warm while serving. "Would they do that in the field?" "Well, in the field, there would be so many people through the line that the beans wouldn't have time to get cold." "I wonder, if it was easy to turn it back on, wouldn't they?"

This test used a non stick griddle. Typically, a regular (not a non-stick) griddle is used; however, the non-stick was what was available. With a regular griddle, additional cooking diligence would be required and possibly, cleanup times would be longer.

B-1.6 Serving

Majority of serving done after 120 people went through (people trickling in after). The condiment layout is shown in **Figure B-8**, the serving layout is shown in **Figure B-9** and a picture of the whole operation can be seen in **Figure B-10**.

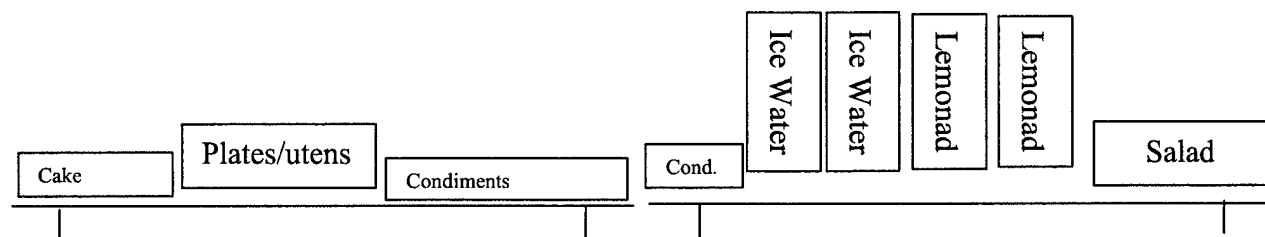


Figure B-8 Items on Condiment Table

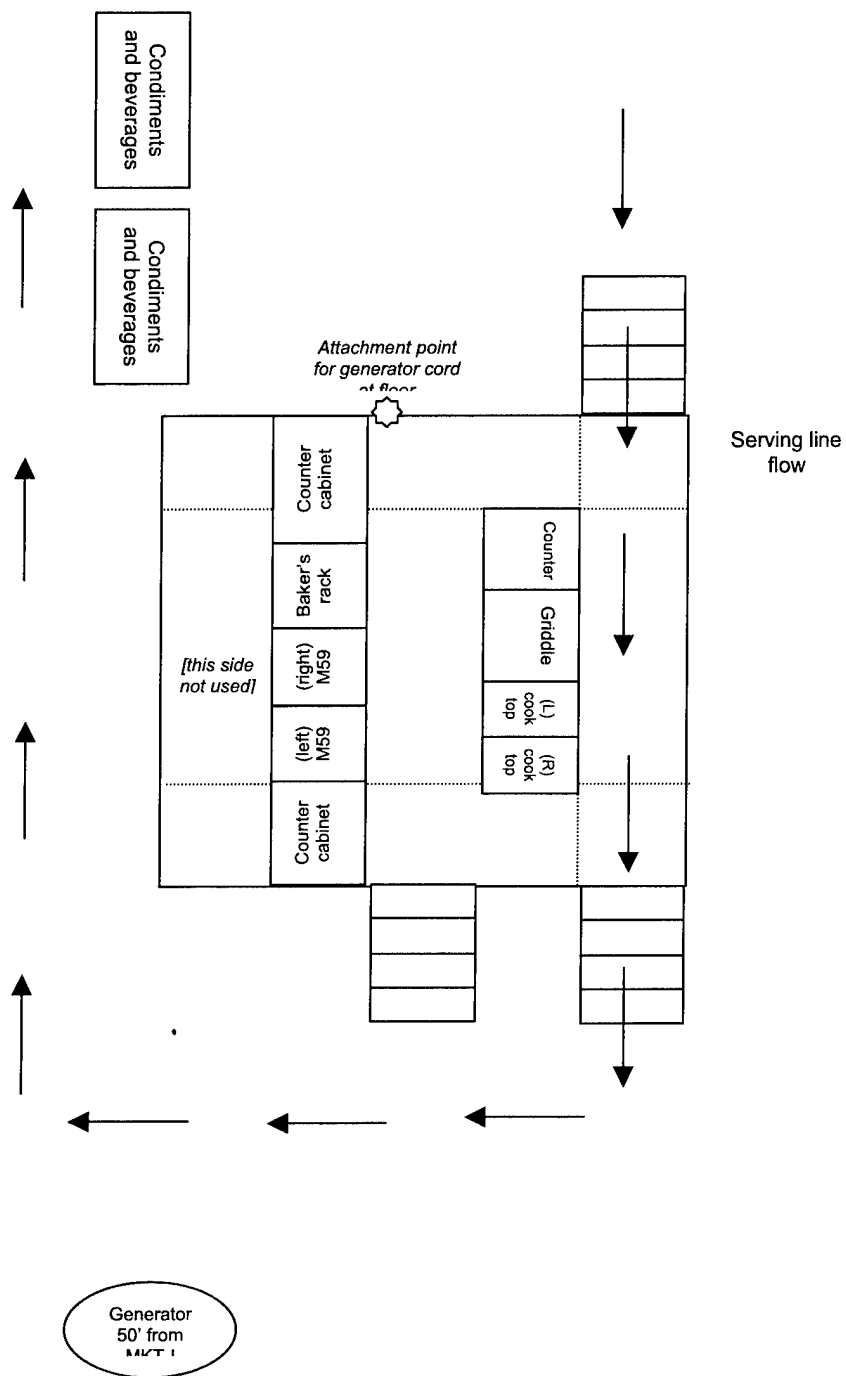


Figure B-9 Layout of MKT-I Feeding Camp



**Figure B-10 Line Leaving MKT Entree Serving Area,
Heading for Condiments**

B-1.7 Clean up

Clean-up began at 12:11 and concluded at 1:15. Unlike when the standard MKT was tested, this time they knew about the grease trap problem, so they propped up the grease collector with a soda cans before cooking. This made clean-up easier and faster due to not much grease drippings.

B-1.8 Pickup

At 12:40, the packing up began by performing the following tasks:

- Take down stair rails
- Take down mosquito netting
- Roll up floor mats [Note: only one of the floor mats was in place (the one for the cooks). The others had just been set aside.]
- Pack/stow equipment [Again, some delay waiting on the clean dishes. At 1:15 all cleaning completed]
- Lower roof

Complete packing up could not be done until all cleaned dishes, pots, etc. were returned from the sanitation facility.

1:40: DONE (This time it WAS lashed properly, and the legs were cranked up).

B-2 Environmental Measurements

Roof vents open entire demonstration

B-2.1 Illumination and Sound

During fueling the sound level was measured to be 98 dB-C next to Frank's ear as he leaned over the unit The noise level in the MKT-I made it difficult to hear each other – need to yell

Light level data is shown in **Table B-1**. Noise level data is shown in **Table B-8 Noise Levels**.

Table B-7 Light Levels

Location	Height	Illumination	Time taken
		(fc)	(hh:mm)
Outside	n/av	219	Start of test
		257	10:30
Center of MKT-I (w/lighting)	Chest height	85	n/av
Center of MKT-I	Chest height	94	10:41
Outside MKT-I (shade)	n/av	300	10:41
Outside MKT-I (sun)	n/av	500	10:41
Outside MKT-I (sun)	n/av	644	12:30
In MKT-I (no lighting)	n/av	7	12:30

Table B-8 Noise Levels

Location	Height	Noise level	Time taken	Comments
		(dB-C)	(hh:mm)	
Inside MKT-I	n/av	80	9:16	No burners lit-idle
1 meter from cold, unloaded generator (idling)	n/av	97.5	9:16	
Center of MKT-I	~ 54 in. above floor	97-98	10:17	Generator and 4 burners lit/1 fueling
Center of MKT-I	~ 54 in. above floor	97-98 dB-C	10:19	Generator and 4 burners lit
Inside MKT-I	n/av	98	n/av	4 burners lit
n/av	n/av	94-97	10:24	Generator and 6 burners lit
Center of MKT-I	n/av	80.5	11:39	Generator on and all burners off

B-2.2 Emissions

Emissions from the MBU burners are shown in **Table B-9**. When taking readings the analyzer will provide an indication of how stable the measurements are. The stability of the reading for the right kettle was poor. The stability for all others was excellent.

Table B-9 Appliance Emissions

Component		Appliance			
		Right Kettle	Left Range	Right Range	Griddle
Time	(hh:mm)	10:30	10:45	10:48	10:50
CO ₂	(%)	2.3	0.8	1.1	5.2
Excess air %		565	1853	1331	199
Flue Temperature	(°F)	n/av	346	383	878
Ambient Temperature		40	45	45	46

An Ecotox gas analyzer was available for checking ambient air conditions inside the kitchen. The analyzer has the capability to measure percentage of oxygen, and parts-per-million (ppm) levels of carbon monoxide, carbon dioxide and nitrogen dioxide. The measurements are summarized in **Table B-10**. When in fresh air the oxygen level was 21.1% and the nitrogen dioxide at 0.1 ppm. When the intake hose for the analyzer was held at face level in the middle of the kitchen the only change was a slightly increased tendency for the NO₂ level to occasionally read 0.2 ppm. When it was held a little lower than face level close by the left range cabinet the O₂ level dropped slightly to 21.0% and the NO₂ level again fluctuated up to 0.2 ppm although more frequently than when the hose was just held in the middle of the kitchen. O₂

Table B-10 Atmospheric Pollutant Levels

Gas Detected	Value Measured	Time taken	Comments
		(hh:mm)	
O ₂	21%	10:26	
	21.10%	10:49	
	20.50%	10:31	
	20.10%	10:49	At side of griddle, lots of smoke
	21.20%	11:11	
NO ₂	0.1 ppm	10:26	
	0.1 ppm	10:49	
	0.3 ppm	10:31	
	1.0 ppm	10:49	At side of griddle, lots of smoke
	0.1 ppm	11:11	
CO	0 ppm	10:29	
	0 ppm	10:31	
	0 ppm	10:49	
	0 ppm	10:49	At side of griddle, lots of smoke
	0 ppm	11:11	

B-2.3 Ambient Temperatures

Overall the day was clear, with dry conditions, and no wind. Temperature measurements are summarized in **Table B-11**.

Table B-11 Ambient Temperatures

Location	Temperature	Time taken
	(°F)	(hh:mm)
	36°F/40°F	Beginning of test
	40.4°F	10:00
Inside MKT-I	69°F	10:32
Outside MKT-I	43°F	10:32
Outside MKT-I	56°F	1:30
Inside MKT-I, in front of burners	56°F	

B-3 Consumed Resources

B-3.1 Trash weight data

Trash may be lower than last test because peaches were never opened. The weight of individual trash is in **Table B-12**; the total weight was 65.5 lbs.

Table B-12 Trash Weight Data

Bag #	Weight	Comments
	(lbs)	
1	22.8	
2	7.06	
3	20.2	
1	15.4	cans

B-3.2 Fuel Weight

Fuel weight calculations are summarized in **Table B-14**

Table B-13 Fuel Transport Can Weight

Can #	Weight		
	Initial	Empty	Refilled from MBUs
	(lbs)		
1	39.2	6.4	21.2
2	42.1	6.0	40.0
3	41.0	6.0	41.8

Some of the fuel was used in the generator.

Table B-14 Fuel Weights

Burner Reference ID#	ID# of Can filled from	Burner Weight				Fuel Used		
		Initial		Final				
		Empty	Full	After Use	After Emptied			
		(lb)				(lb)	(gallons)	
-21	3	37.9	54.8	51.8	37.9	2.99	0.4	
-3	2	38.1	55.0	51.9	38.2	3.07	0.5	
-23	3	37.9	54.7	52.8	38.0	1.84	0.3	
-19	3	37.8	54.6	52.8	38.0	1.79	0.3	
-11	1	38.1	54.8	52.2	38.2	2.57	0.4	
-18	1	38.0	54.7	51.5	38.0	3.18	0.5	
			Total consumption:				15.44	2.3

B-3.3 Demographics

Compared to the last test (MKT with M2 burners), the participants doing the work are less experienced. Some time spent learning how to set up the trailer could have been used to set up the generator. The demographics are summarized in **Table B-15**.

Table B-15 Demographics

Cook #	Role	Sex	Height	MOS	Yr in MOS	Name
			(in)			
1	Supervisor	M	69	92G	3	Dave Villar
2	Cook	M	70	Civil.	n/av	Frank DiLeo
3	Cook	M	71	Civil.	n/av	Dan Gauvin
4	Cook	M	73	Civil.	n/av	Chad Haering
5	Cook	M	n/av	Civil.	n/av	Norm McGowan

Appendix C - Demonstration of the CHUCK Wagon [January 27, 2000]

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Appendix C Demonstration of the CHUCK Wagon [January 27, 2000]

C-1 Timed Tasks

The CHUCK Wagon consists of the following cooking appliances, permanently mounted on the trailer:

- (1) 44"W x 21"D griddle,
- (1) Convection oven with a capacity to hold 4 full size sheet pans
- (2) 20 gallon kettles.
- (1) hand-washing sink, with an onboard hot water tank.

The CHUCK Wagon was located inside an enclosed breezeway on concrete flooring. Internal ambient temperature was 55°F. Doors were opened in the breezeway throughout the cooking process in order to ensure adequate ventilation.

C-1.1 Setup

8:41 – begin setup

Three people released flooring from rear of trailer (2 rectangular pieces and 1 triangular piece); as illustrated in **Figure C-1**. The feet are then inserted into the platforms (**Figure C-2**) and the platforms placed around the trailer. The side awnings are unhooked and loose components, such as the leveling jacks (**Figure C-3**) are taken out and organized while other cooks raise the sides (**Figure C-4**) and secure the awnings (**Figure C-5**, **Figure C-6**, and **Figure C-7**). Greater details follow.

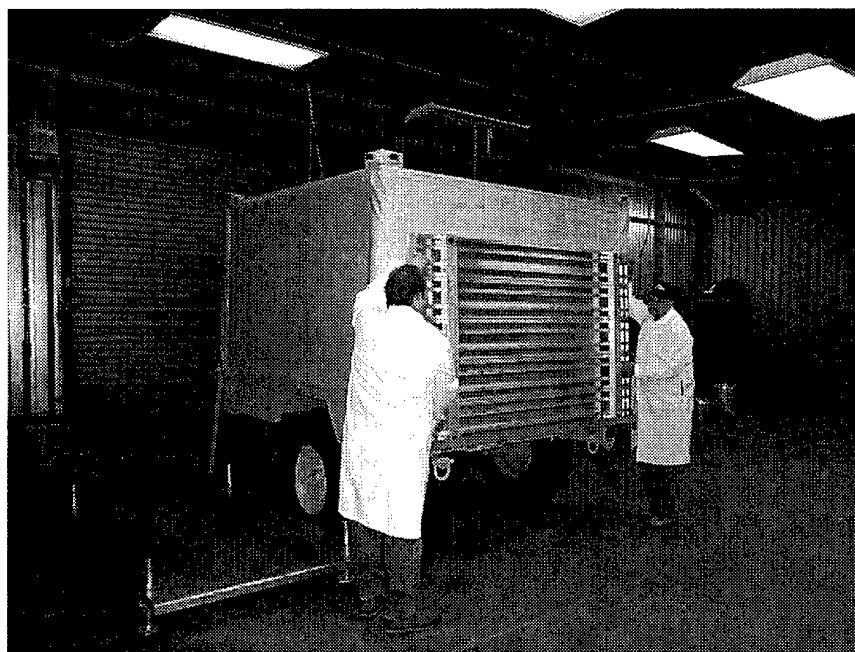


Figure C-1 Removing Flooring off Rear of Trailer

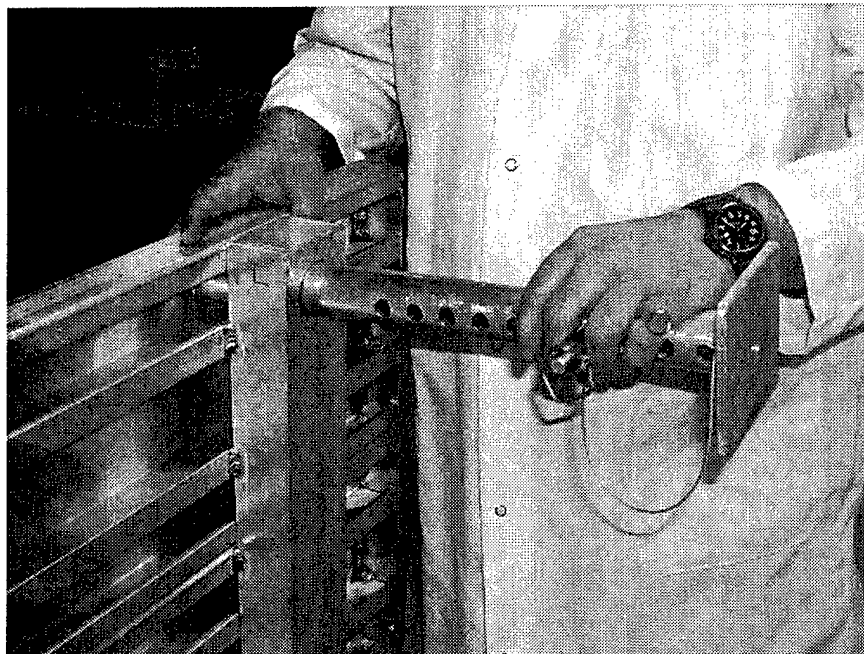


Figure C-2 Inserting Foot into Platform

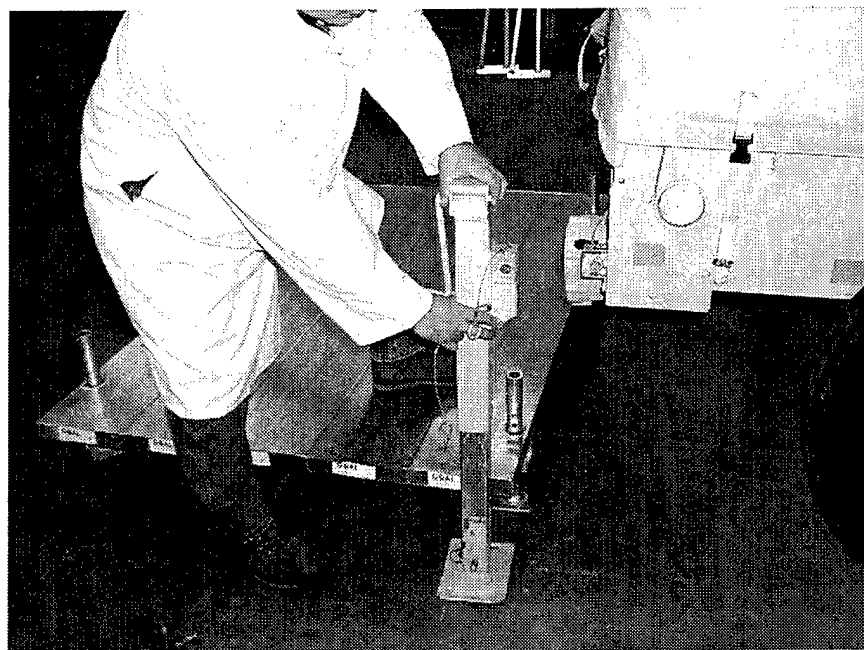


Figure C-3 Installing Leveling Jacks

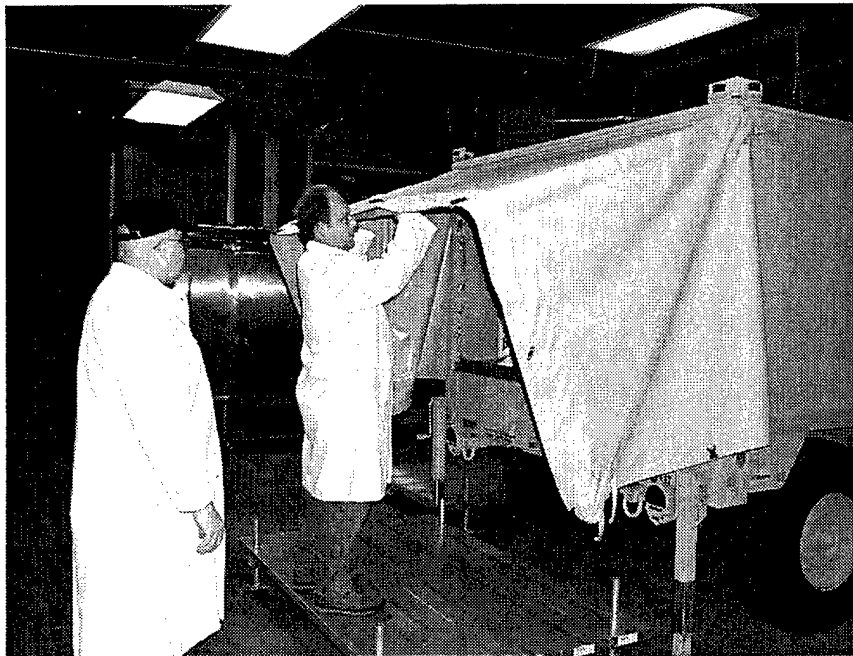


Figure C-4 Lifting Rear Awning



Figure C-5 Securing Awning Supports



Figure C-6 Installing Corner Support

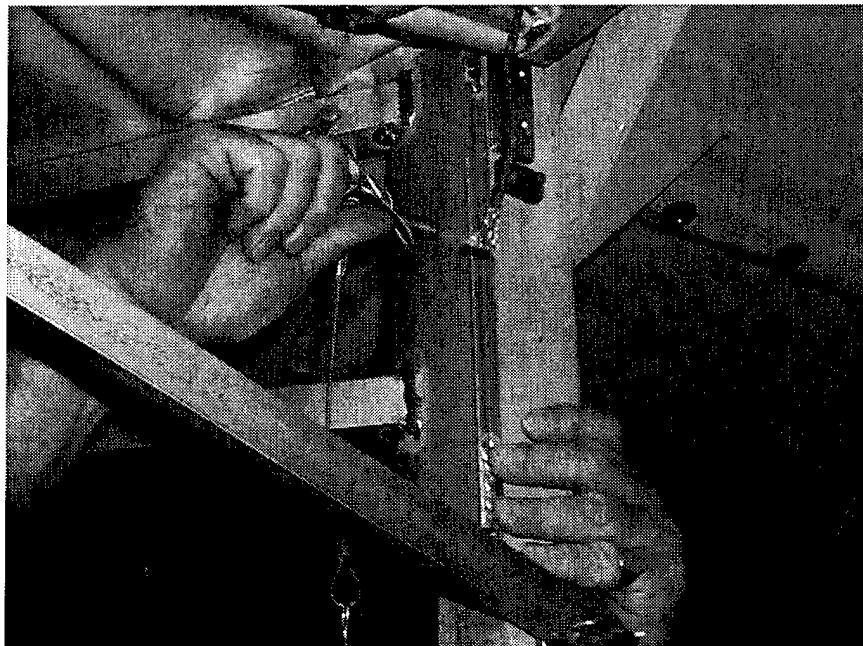


Figure C-7 Securing Corner Support with Pins

8:43 –Unpacked contents from within – four people participating at this point. Items such as pots and tables, Cambros and Insulated Beverage Containers are removed from storage. While most large items are stored above the griddle(**Figure C-8** and **Figure C-9**) and kettles in the cooking area, there is a storage cabinet above the oven which is converted with shelving units to provide a place to store trays of food during meal preparation (**Figure C-10**).

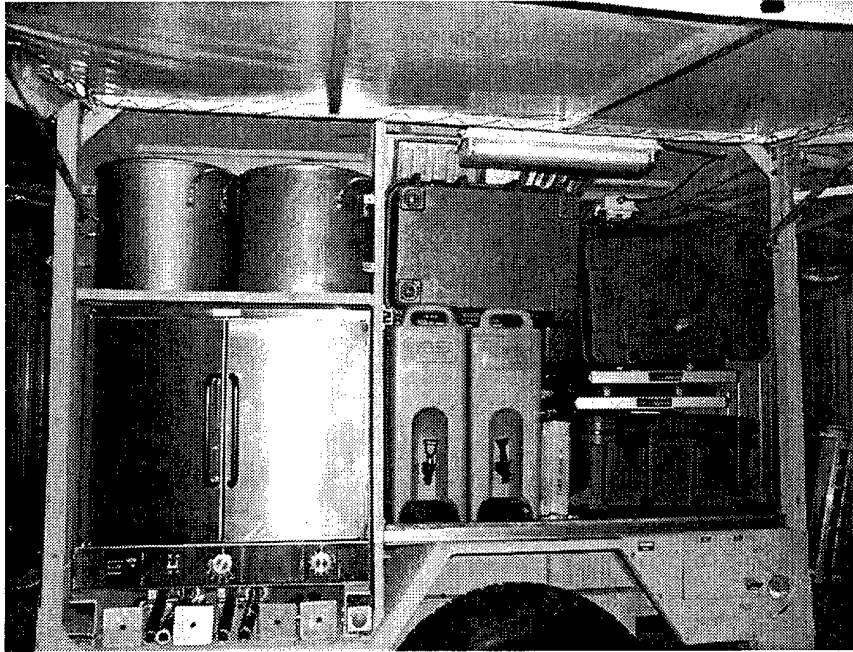


Figure C-8 Storage of Equipment Above Oven and Griddle

8:44 – Attach ground cable to kitchen, in order to begin start of engine

8:45 – Begin process of starting engine (turning switch at control panel, then initiating engine) (**Figure C-11**)

8:46 – Engine started

Installing drain pipes for the kettles – used a large wrench to do this

Filling Cold water tank on trailer with a hose

Open valve to pump cold water from tank into hot water heating tank

8:47 – Flooring down/tables set up

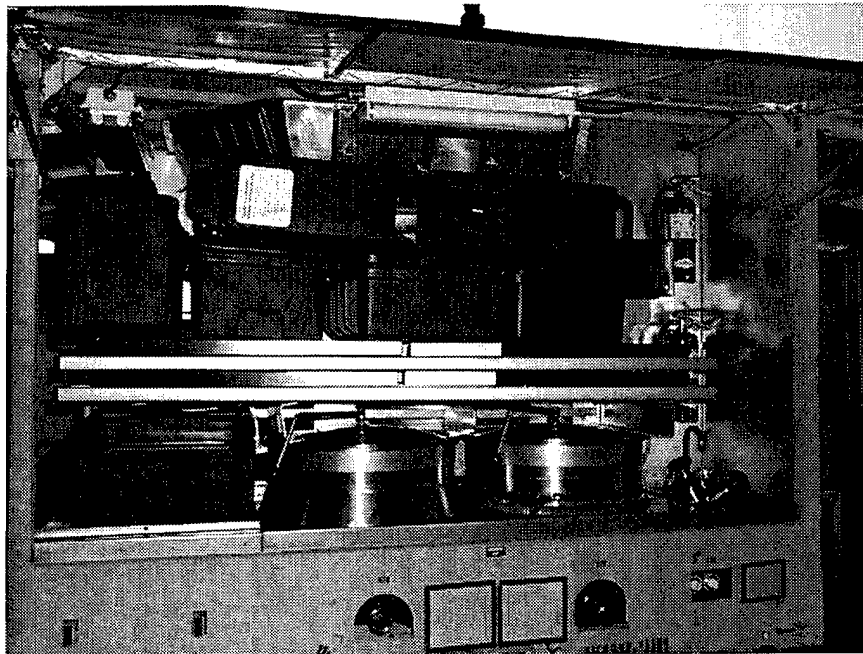


Figure C-9 Storage of Equipment Above Kettles

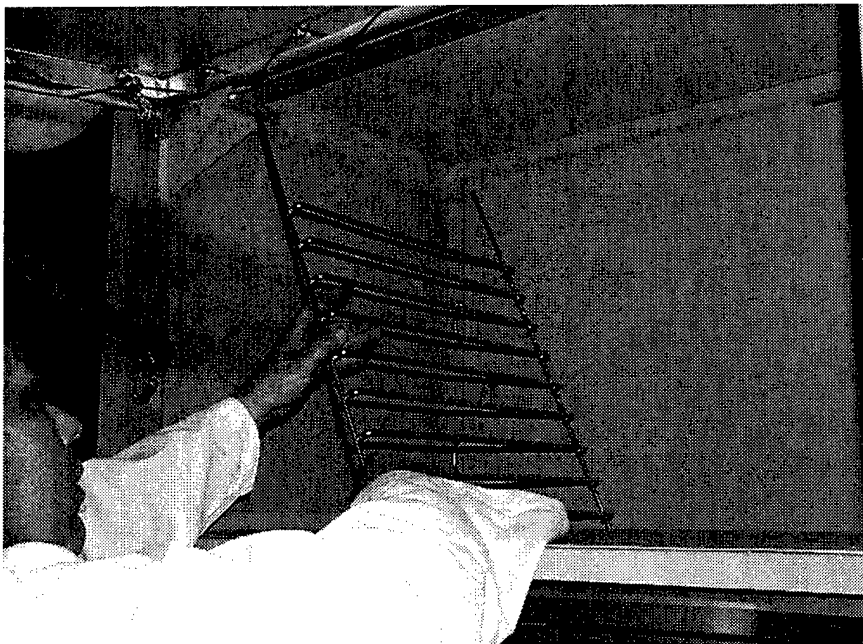


Figure C-10 Shelving Racks to Store Trays of Food

8:50 – Turned on pump for thermal fluid

Putting corner supports on canopy - needed a hammer to do this (the holes were somewhat tight). Installing corner supports requires 2 people – 1 to hold the canopy up and the other to install the pins

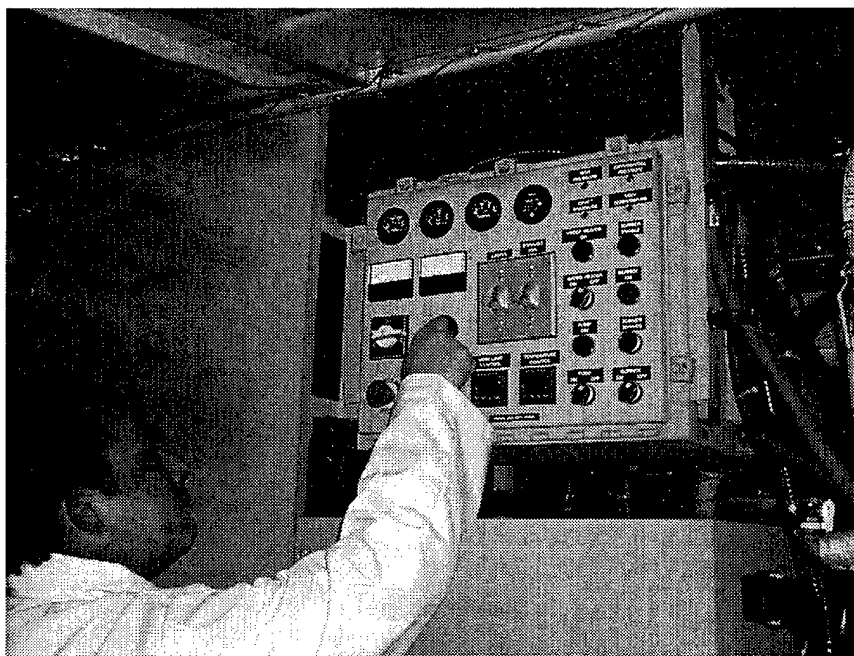


Figure C-11 Starting the Engine

Canopy around cooking areas extends 48" outward from the trailer and is ordinarily surrounded by a shelter wall, but that piece was not available for this test.

8:52 – Alan LaBrode takes all beverage Cambros to FED kitchen to prepare the drinks

8:54 Lights are turned on and Set-up is complete. The layout of the flooring and kitchen appliance is shown in **Figure C-12**.

During set-up, flooring is installed around the work surfaces where the cooking appliances are located in order to facilitate proper working surface heights of the appliances for the cooks. For example, without the flooring installed, the griddle surface is 45" above the ground (too high for the cooks). With the flooring installed, the surface height is 37" above the surface (which is appropriate for cooks) In addition, this flooring allows for the cooks to stand up off of the ground/terrain. The rectangular flooring pieces are held up in each corner by round tubes. These tubes were 15" high and protruded approximately 6" above the flooring surface at each corner. The corner flooring piece hooks directly onto the

two rectangular pieces and is remained firmly in place by this attachment. There exists a tripping hazard with the 6" tubing protruding from the floor. The hazard may be lessened when the fabric walls are in place, otherwise, the design should be modified to eliminate (or at least minimize) this hazard.

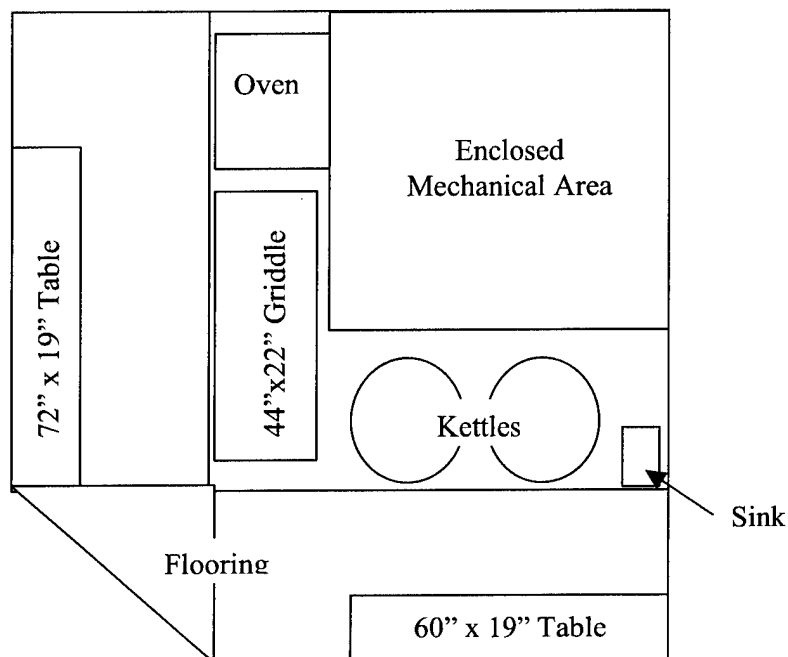


Figure C-12 Kitchen Layout

Two tables, each measuring 71 ½" long x 19 ½" wide x 34" high (heights are adjustable) are provided. These tables are used for food preparation and serving. During food prep, the tables were placed behind the flooring surfaces, parallel to the respective cooking area. At times, the tables were moved up onto the flooring in order to be closer to the cooking areas. After cooking was finished, the tables were set up together in a long line to hold the food for serving. The tables have Roman Style legs to prevent tipping when on the platform (**Figure C-13**).

Although this feature was not available during this technical demonstration, it should be noted here that as part of the setup procedure, a one-hand operated hinged tray may be unclipped from underneath the trailer and swung into position for catching grease from the griddle (**Figure C-14**).

The hand sink measures 9"W x 9"L x 5"D. It has hot & cold knobs and a spray hose. Similar to the grease trap, the sink has a drain hole, with nothing below to catch whatever goes down the drain. A pot was placed below it to catch any draining.

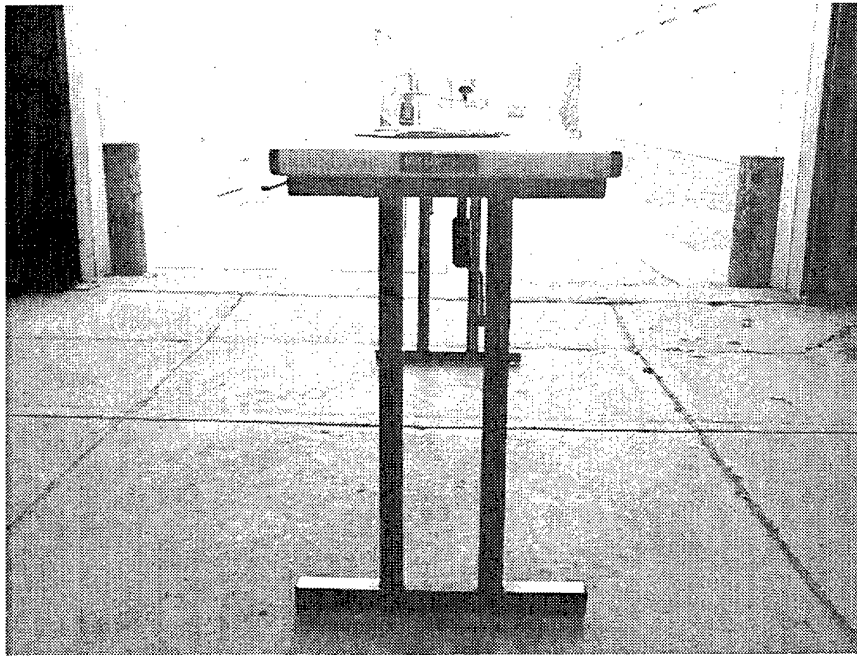


Figure C-13 Roman Table Legs

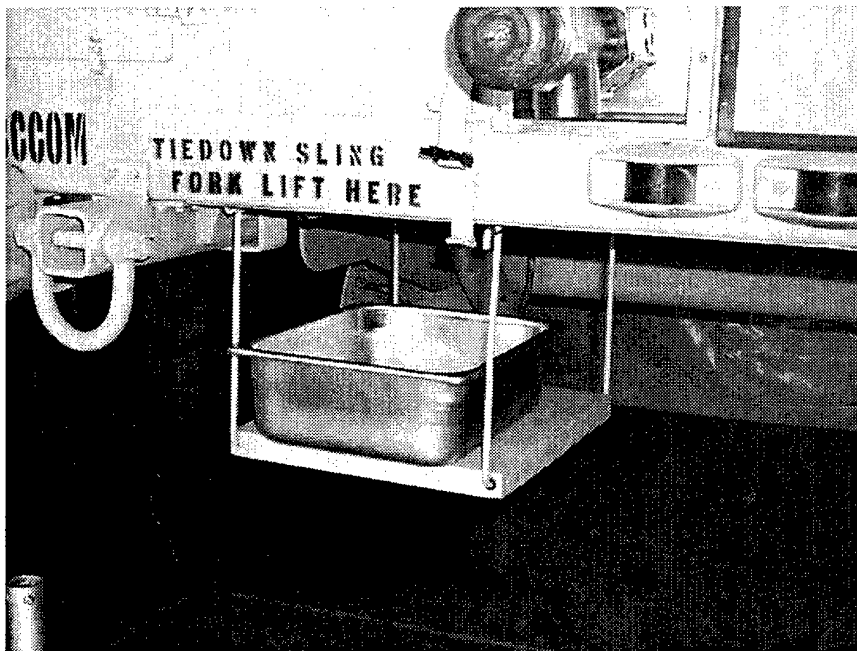


Figure C-14 Catch Basin Beneath Grease Drain Hole

There is fluorescent lighting above the kettles and griddle; and there are two fire extinguishers above the sink in the corner.

It is recommended that the hooks provided above/near the cooking areas for hanging utensils be changed from individual hooks to a longer, bar-type design. This will allow the cooks more flexibility (as to where they place their utensils), and will require less precision when hanging or removing the utensils.

Total Time for Setup is approximately 13 minutes

of people participating in set-up was 3 to 5.

C-1.2 Meal Preparation

8:52 – Food Preparation Begins

C-1.2.1 Kettles

There are two 20 gallon jacketed kettles. The kettle drains are attached during set-up, and they protrude approximately 8 ½” out from the trailer. A perspective of their location can be seen in **Figure C-15**.

8:59 – Filled Right Kettle with 10 gallons of water for coffee, with a water hose (not part of the CHUCK Wagon) located within the building. Turned Right Kettle on High Setting

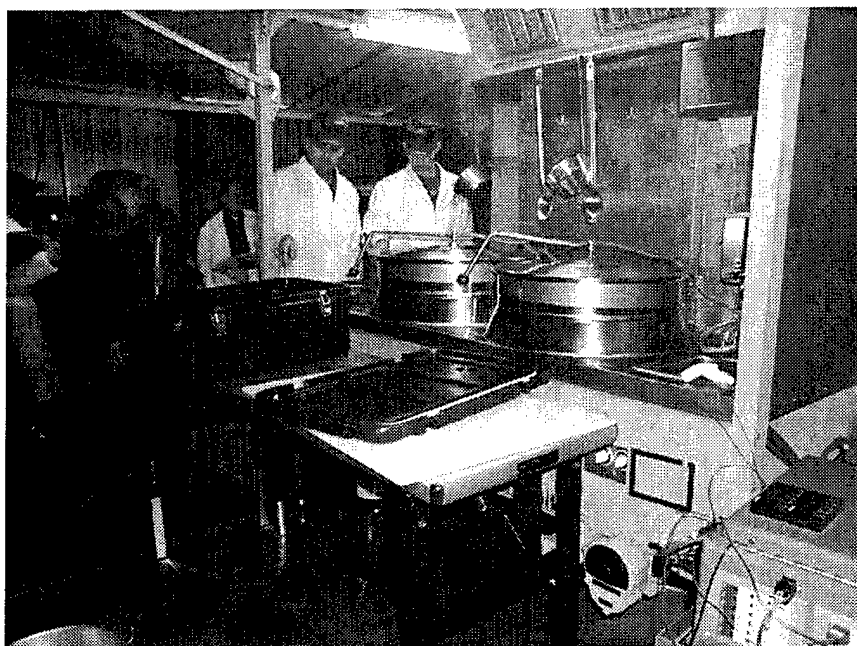


Figure C-15 Overview of Operations

9:13 – Water starting to form little bubbles/boiling with steam forming – lid was open.

In order for the right kettle's lid to stay open, it was tied up – apparently when it was taken apart previously, it was not put together properly and the “stay-open” feature wasn't working properly.

9:19 – Opening 6 - #10 cans of baked beans – used table mounted can opener (E110 model).

Beans placed in the left kettle, but did not turn on heat to the kettle yet. The beans and corn in the left and right kettles is shown in **Figure C-16**.

9:20 – Turned off Right Kettle and drained water from the right kettle into a stockpot (which was placed below under the drain) to make coffee.

Weight of stock pot with coffee is 65.58 lb.

Draining the water created a lot of steam, so at 9:21, the exhaust fan was turned on the help remove the steam, which did seem to help. The switch for the exhaust fan is located around the side of the Chuck Wagon at the main control panel.

9:27 – Opened 6 - #10 cans of corn



Figure C-16 Kettles with Beans and Corn

9:34 – added corn to right kettle but did not turn heat on yet.

9:19 – Opening 6 - #10 cans of baked beans – used table mounted can opener (E110 model).

Beans placed in the left kettle. Not heating yet.

9:20 – Turned off Right Kettle and drained water from the right kettle into a stockpot (which was placed below under the drain) to make coffee.

Weight of stockpot with coffee is 65.58 lb.

9:21 – Draining the water created a lot of steam, so the exhaust fan was turned on the help remove the steam, which did seem to help. The switch for the exhaust fan is located around the side of the Chuck Wagon at the main control panel.

9:27 – Opened six #10 cans of corn

9:34 – Added corn to right kettle but did not turn heat on yet.

9:45 – Turned both kettles on low setting (#1 on the knobs)

9:50 – Steam rising from the beans in the left kettle.

9:52 – Beans seemed almost cooked – bubbling around the edges in the kettle. Need to remember to stir food, such as beans to ensure uniform cooking – the beans on the surface of the kettle cook quickly, while those in the center are not getting cooked yet. Steam is rising from the corn in the right kettle.

When stirred, temp of beans is 90 F and temp of corn is 150 F.

Turned kettles off, but then turned them right back onto the lowest setting.

10:02 – Turned right kettle off.

10:05 – Turned left kettle off.

Even though the kettles were turned off, they still retain the heat and keep cooking the food.

Temperature of the beans was 174°F and the corn was 198°F.

10:31 – Beans were ladled out of kettle into a Cambro serving tray. This was a bit awkward and required two people to do – one who holds the tray up against the kettle and the other, who ladles the beans out of the kettle.

10:41 – Attempted to remove corn from kettle by draining it through the bottom, but couldn't do it this way because the drain got blocked up. Needed to ladle the corn out also. This blockage may be seen in **Figure C-17**.

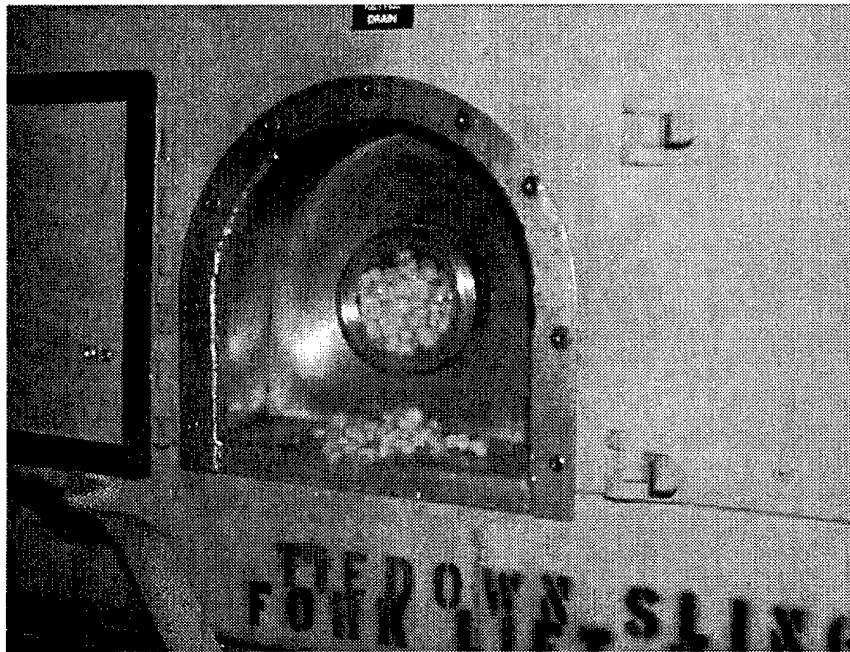


Figure C-17 Corn Clogged in Standard Commercial Drain

Whether food is being ladled out or drained from the kettle spigots, there is an issue that should be noted. In the first instance there is nowhere to set the serving container while food is being ladled into it. And in the second case, there is nowhere to set the container on the floor without risking the liquid splattering, or the container tipping if placed too far under the spigot (and falling off the flooring.). In the case of ladling food, if two cooks are there, both holding one side of the serving container, and one of them is also ladling the food, there is the risk of dropping the serving container, and scalding one or both of the cooks. (not to mention wasting the food, and causing a mess).

10:53 – All beans out of kettle. Needed two Cambros for the beans. Got most of the beans out, but the remaining food debris continues to cook onto the sides of the kettle. One idea to prevent stubborn build-up of the beans on the kettle is to fill the kettle with water and let it soak. However, that will use up a great deal of water. Otherwise, the cooks are required to scrub it clean. This is do-able, but is difficult given that the kettles retain heat, and also cannot be removed to facilitate cleaning. In addition, a method must be developed to ensure that the kettle drains are properly cleaned.

10:56 – Sprayed water into the left kettle so that the cooked food debris doesn't harden up too much.

11:00 – Cleaning left kettle

11:07 – Cleaning/emptying right kettle

C-1.2.2 Oven

The oven dimensions were 31”W x 24”H, with a capacity to hold 4 full size commercial sheet pans. The bottom of the oven was approximately at the same height as the griddle surface. Above the oven, is an empty, open space, perhaps a warming space for trays coming out of the oven. There are no shelves. The dimensions of this space are 32”W x 21”H x 24”D.

8:57 – Oven turned on to 375°F with fan on high

Oven has four tray racks capable of holding four full sheet pans

Exterior oven surface at bottom of doors – heat is emitting out of door – 225°F. Surfaces at lower, left bottom are hot

9:01 – Preparing Cake mixes

Using hose sprayer at sink, filled a pot with water and ladled this out for cake mix.

Used 3 – 5 lb boxes of Devil’s Food cake mix – 1 cake mix per full tray

9:15 – Turned oven temperature down to 300°F.

9:28 – Noticed oven light off – this indicates that it’s up to temp (300°F)

9:30 – Put 3 trays of cakes into oven and set the timer for 20 minutes; switched fan setting from high to low

1st cake on bottom shelf

2nd cake on middle shelf

3rd cake on top shelf

9:49 – Checked on cakes, but not done yet. Note: there wasn’t enough light to see clearly into the oven, although the ambient room lighting was adequate. Recommend that a light be incorporated into the oven cooking area.

Also, note: the cooks never heard the oven buzzer from the timer go off. Perhaps integrate a flashing light with the timer to indicate when the timer goes off.

10:02 – Top cake out of oven

Moved middle cake to 2nd from top rack.

Moved bottom cake up one to middle.

10:13 – Put first cake that was taken out of the oven, back into the oven onto the bottom shelf, because it wasn't consistently cooked throughout.

10:26 – All cakes are taken out of the oven. Turned oven off.

No place to put the cakes – the table was being used to hold the boxes of burgers that were awaiting to be cooked, and the cook did not want to place any of the cakes in the open area above the oven because he thought that the temperature on that shelf was too hot – it was 112°F

C-1.2.3 Griddle

The griddle surface is 44"W x 21"D. There is a grease trap at the right end, which is 3"W x 22"D and sinks down 3" in depth. At the back corner of the grease trap is a hole, where the grease will drain through. There is nothing below the hole to catch the grease. The grease will drip right onto the ground. For this demo, an empty #10 can was placed below the grease hole to catch the grease. The griddle with a full load of burgers is shown in **Figure C-18**.



Figure C-18 Griddle with Full Capacity of Burgers

Located above the cooking areas are the exhaust vent fans. Incorporated into the exhaust vent fans is a grease trap, aimed at collecting grease that is sucked up into the vents. When

the vents are on and there is a lot of exhaust being pulled upwards, it appears that the grease traps interfere with the airflow into the exhaust fans. The flow is illustrated in **Figure C-19**.



Figure C-19 Flow of Cooking Fumes to Hood

A convenience (electrical) outlet is provided in the griddle control panel. What is its purpose? The cooks indicated that they did not know what they would ever use it for. Recommend: 1) it be a GFCI (Ground Fault Circuit Interrupter) outlet (generally required of any outlet within 6' of water. 2) the outlet face downwards (perhaps be mounted underneath) so that if anything is plugged in the wire does not stick out, and also is less likely to create a tripping hazard. 3) may want to consider putting a self-retracting cover plate over the outlets to minimize wear and tear during transport, (especially if the outlet were to be located outside the protective box or under the trailer).

9:46 – Turned Griddle on to 350 F

9:50 – Griddle surface temps were measured at three locations on the griddle as follows (**Figure C-20**):

297 °F	302 °F	325 °F
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Figure C-20 Griddle Temperatures - Set 1/2

9:55 Three more griddle surface temps were taken as follows (**Figure C-21**) :

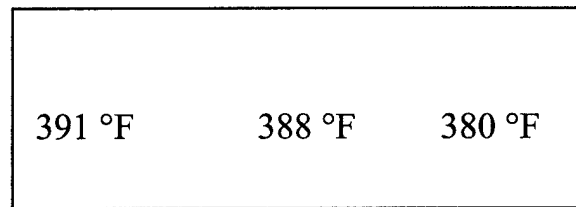


Figure C-21 Griddle Temperatures - Set 2/2

9:57 – First Batch of Burgers placed on the grill. 36 burgers filled the griddle (4 deep x 9 across)

10:00 – Griddle surface temp at middle is 384 F even though temperature setting is set at 350 F.

10:03 – Two people flipped burgers.

10:04 – Lowered griddle temp to 300°F.

10:07 – Removed 1st batch of burgers from griddle and placed them in a Cambro.

Scraped down grease on griddle – scraped from front to back and left to right. The grease splashes over the back guard behind the griddle, and into the area behind the left kettle. In addition to increasing the cleaning burden, there is also the possibility of a grease fire, though remote due to zero ignition sources. Recommend a higher backsplash be provided.

Doesn't seem as if the griddle has enough incline to the right in order for the grease to flow into the grease trap.

The griddle has a channel for grease to flow to the trap along the front edge. Recommend a channel along the back edge as well. The flow of grease is being restricted by the food being cooked on the griddle.

Grease trap at right has a hole in the back end for the grease to drain through. However, there is nothing under to catch the grease – it would spill freely onto the ground. For this demo, an empty #10 can was placed on top of a small trashcan and placed directly below the hole to catch the grease emptying out.

10:10 – 2nd batch of 36 burgers placed on griddle.

10:17 – Flip Burgers – Lot of steam generated from the hot grease – exhaust could be a bit stronger.

10:20 – Burgers off the griddle – grease is moving a little more on its own to the right, but griddle still holds a lot of the grease.

10:22 – Scrape down griddle; griddle surface temp is 360°F, but control knob is at 300°F. Griddle temperature is not calibrated correctly.

10:24 – 3rd batch of burgers on griddle – 32 burgers this time. When burgers are added, the surface temp remains the same – cold burgers did not draw down the heat.

10:30 – Flip burgers.

10:34 – Remove burgers from griddle, then scrape grease off of griddle.

During the burger cooking/removing from griddle process, the serving table located behind the kettles was moved up against the rear of the CHUCK Wagon and the burger Cambro was placed on the end – this allowed the cook to remove burgers and place them easily into the Cambros. This was not an optimal location for the table since it blocked access to the kettles. When it was time to remove food from the kettles, they had to move the table back out of the way again. At this point, the Cambro was moved to the serving table behind the cook. When removing the burgers, the cook had to pick up the burgers with the spatula, turn 180 degrees and place the burgers behind him into the Cambros – this allowed grease drippings from the spatula/burgers to drop onto the floor surface where the griddle cooks were standing – this made the floor slippery. It is recommended to explore the option of providing a slide out table, or surface, which could clamp onto the trailer near the griddle to facilitate moving food into the Cambros from the griddle.

10:37 – 4th batch of burgers on griddle – 35 burgers.

10:43 – Flipping burgers – lot of steam – flowing out from under awning.

10:47 – Burgers removed from griddle.

10:49 – 5th batch of burgers on griddle – 35 burgers.

10:57 – Flipping burgers.

10:59 – Burgers removed from griddle.

11:01 – 6th batch of burgers on griddle – 36 burgers.

11:07 – Flipping burgers.

11:08 – Twelve more burgers placed on griddle.

11:10 – First set of 36 burgers taken off the griddle.

11:11 – Additional 19 burgers placed on griddle (now there are 31 burgers on griddle).

11:14 – Flipped set of 12 burgers.

11:16 – 12 burgers off griddle.

11:16 – **Turned griddle off.**

11:17 – Flipped last 19 burgers.

11:19 – Griddle surface temp is 340°F.

11:20 – 19 burgers off griddle.

11:20 – Cooking burgers completed – Total of 241 burgers cooked in 1 hr & 23 min.

C-1.2.4 Other Food Prep Processes:

9:32 to 9:44 – Started preparing lettuce and putting in 2 flat Cambros with 3 compartments, each (2 soldiers doing this).

(4) Cambros with beverages: 1 water, 1 punch, and 2 lemonade.

11:17 – Serving Station is Set-up.

C-1.3 Serving

11:21 – Serving Starts – two servers – one dishing out burgers/another dishing out the corn & beans. Served 106 people (37 of them ate two burgers)

Exhaust fans are still on.

11:25 – Turned off the exhaust fans & burners, but left the thermal fluid on.

The serving table setup consisted of two tables placed together with the following items in this order: condiments, napkins, plates, cheese, rolls, burgers, salad, beans, corn, cups, beverages.

There was no room on the tables for the cakes, coffee & fixings, or peaches (which actually were not served during this demo as was during the other two demos). They were placed on another surface, not part of the CHUCK Wagon.

11:55 – Lot of food still left, but no serving – no people showing up.

C-1.4 Clean up

Clean-up could have started while the two servers were serving food, but the other cooks/participants had to leave.

11:55 – Frank started clean-up by scraping down griddle.

12:30 – Generator set turned off.

If the spigots to the kettles are removed and liquid is drained from the kettles via the drains, the liquid spills over the taillights. Although the taillights are designed to resist weather, having food products poured over them probably isn't good either.

12:35 – Stopped cleaning, but waiting for the dirty dishes being washed in the kitchen.

C-1.5 Packup

12:35 – Started tearing down/disassembling/pack-up – Three people doing this. Disassembled floor during cleaning – only took a few minutes to do this.

12:40 – Disassembling awning frame. The holes for the pins that connect the purlins to the uprights need to be made slightly larger. Needed a hammer to remove (bang out) the pins which were holding up corner supports on canopy. Also, since flooring had been removed, needed to use a step stool to reach.

Alex removed, cleaned and replaced the overhead vent/grease trap covers. Alex is 5'9" and did not have trouble doing this

12:45-12:48 – Paused, awaiting return of cleaned dishes.

12:48-12:52 – Some dishes back, and packed them up.

12:52-13:19 – Paused, waiting on remaining dishes to be cleaned and returned.

13:19 – Continue with strike/pack.

Load up: 4 Cambros, 6 beverage containers, 2 tables and 2 awning supports.

Other items (not inventories) will go in the support vehicle.

1:24 – Lowered awning fabric and secured to outside trailer. The female ends of the buckles are difficult to grasp and hold while securing. A small pull-strap would help especially if wearing gloves.

1:27 – Stowing flooring

Flooring is loaded onto a rack that is secured to the back of the trailer. However, if only one or two of the three pieces are in place, someone must hold them, or they will fall. If they fell onto someone they would cause serious injury. Recommend designing the rack such that they won't fall while being stowed.

The flooring pieces were secured via bungee cords at the top corners. Recommend a better securing methodology be developed, as bungee cords can present risks, and it is doubtful that the system would pass transportability testing with the bungee cords in place.

1:28 – Finished packing up – demo over – Total Overall Time of Demo = 287 minutes or 4 hour and 47 minutes

C-2 Environmental Measurements

Environmental measurements are covered in more detail in **Appendix 4**.

C-3 Consumed Resources

C-3.1 Ancillary Tools/Equipment

Very Large Wrench – used to connect and disconnect the kettle drain spigots.

Step Stool – used to reach the roof canopy/awnings in order to remove the pins which held them in place.

Hammer – used to bang the pins (used to hold the canopy/awnings up) out from the hole – either the pins are too big or the holes too small – need to be adjusted in future designs.

Fantastik® Cleaner – to clean surfaces

Used a different spatula than the one provided

C-3.2 Fuel

Two 5-gallon containers full of diesel fuel provided with the Chuck Wagon. One each hooked up for the burner and the generator. Both 5-gallon containers were filled and weighed prior to start of the demo. A summary of fuel consumed is shown in **Table C-1**.

Table C-1 Fuel Consumed

Fuel Container	Fuel Container Weight		
	Start	End	Difference
Generator Set	39.26	31.03	8.23
Burner	39.46	25.07	14.39

C-3.3 Demographics

Table C-2 Demographics

Cook #	Role	Sex	Height	MOS	Yr in MOS	Name
			(in)			
1	Supervisor	M	69	92G	3	Dave Villar
2	Cook	M	70	Civil.	n/ap	Frank DiLeo
3	Cook	M	n/av	92B	0.8	Bennett
4	Cook	M	n/av	Civil.	n.ap	Al Labrode
5	Cook	M	n/av	92A	n/av	Main
6	Cook	M	n/av	Civil.	n/ap	Steve Sargent

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Appendix D Environmental Conditions During Kitchen Operation

D-1 Introduction

A primary factor effecting personnel performance during operations in any kitchen, is comfort, particularly with regard to environmental conditions such as air quality and sound level. This appendix covers monitoring for both these factors and summarizes results found in all three demonstrations.

D-1.1 Air Quality

Air quality is effected by two variables; circulation through the area, and gaseous products generated either from cooking food or the heat-source combustion process. During these tests an attempt was made to measure air quality, but results are withheld from this report due to lack of confidence in the instrument accuracy. Had better tools been available, such things as humidity from boiling water, and carbon monoxide and hydrocarbons from combustion processes may have been quantifiable. Humidity merely effects comfort whereas combustion products will effect a cook's health. Burnt or otherwise liberated grease compounds can also be a hazard.

Even if we had been able to monitor these constituents, a plethora of variables effecting kitchen ventilation could not have been controlled from test to test. These include wind velocity and interior/exterior temperature differences. Controllable variables are shelter configuration, rate of food preparation and entrance/egress frequency. As it was, both MKT tests were performed with the side walls rolled up, so there was no appreciable difference between overall interior conditions and outside air.

Even so, it is widely accepted that the venting of combustion products in the vicinity of people, is unwise; despite complete ventilation there remains a danger of cooks directly inhaling combustion products leaking around the edges of appliances. The M2 burners consume automobile gasoline, replete with toxic additives; cooks have expressed an opinion that these fumes are less palatable than those from the diesel fired MBU.

The amount of pollutants produced is directly related to fuel consumption rates and appliance efficiency, and can be an indicator of kitchen interior air quality. Exhaust and efficiency for each MKT burner was measured. Results are presented in **Table D-1**, but it must be pointed out such measurement are more a laboratory exercise.

Table D-1 Combustion Emissions

Trailer	Appliance	Time	CO2 %	Excess air %	Flue Temp °F	Ambient °F
		(hh:mm)	(%)	(%)	(°F)	(°F)
MKT w/M2	Right Kettle	11:07	3.5	268	195	70
	Left Range	11:08	0.6	2196	195	70
	Right Range	11:14	0.7	1871	318	71
	Griddle	11:28	2.6	401	520	76
MKT w/MBU	Right Kettle	10:30	2.3	565	n/av	40
	Left Range	10:45	0.8	1853	346	45
	Right Range	10:48	1.1	1331	383	45
	Griddle	10:50	5.2	199	878	46
CHUCK	Boiler	n/ap	12.1	28	617	59

Ideal diesel combustion conditions result in production of 12% CO₂ with 35% excess air. Too much excess air will rob heat from the flame and so prevent its productive use by the appliance. Too little excess air will stifle air/fuel mixing and cause incomplete combustion. With either MKT burner there is likely to be complete combustion; however the amount of open space around the kettles and griddle causes losses due to heating of influx air and leakage around the appliance. The range cabinets would be slightly more effective. Newer appliances, better able manage the combustion processes and heat flow, and able to vent exhaust outside the enclosure, are currently under development for the MKT.

Data for CHUCK Wagon combustion was taken the previous day under conditions similar to the actual technical demonstration exercise. Because all CHUCK combustion products are tightly contained and vented outside the cooking area, accurate measurements were possible. Furthermore, the CHUCK Wagon has a full hood with exhaust fan over the griddle and kettles for venting steam and grease vapors produced during food preparation.

It has been determined in more carefully controlled tests that efficiency of the burner/appliance systems, that is, the amount of useful heat extracted for fuel used, is less than 20% for either M2s or MBUs (used in currently fielded appliances), and as high as 65% for the CHUCK wagon.

D-1.2 Sound Levels

Two factors, magnitude and quality, must be considered when discussing sound levels. Magnitude is easily measured; quality is more subjective because of the human ear's selective sensitivity to certain frequencies. A sound source dominated by these frequencies will appear louder than one which is not, even when the intensities are equal. To account for this effect,

standards organizations have developed weighting scales for sound measurement, and the sound meter used in this test contained electronics to simulate A and C weighting scales.

The A-weighting scale is used by OSHA because it places emphasis on frequencies above 500 Hz, ultimately representing sound most related to hearing damage and annoyance levels. Some sounds we find annoying, however, do fall outside this array. For instance a rattling noise recently eliminated from the CHUCK Wagon resulted in a distinct perceived sound level decrease, yet hardly registered during A-weighted sound measurement. In any case, readings taken during this test will be presented in decibels of the A-weighted frequency spectrum, commonly abbreviated as dB-A.

Data for MKT sound levels are shown in **Table D-2**. Original measurements taken during M2 operation were in dB-A. MBU measurements were in dB-C and converted to dB-A for comparison. Due to the volume of data available, the conversion accuracy is acceptable. For example, previous tests showed 77 dB-A for the noise level of a single MBU at one meter. The theoretical combination of six such identical sources would raise the level to 80 dB-A. A study performed during an actual field exercise places the noise level of six burners in an operating kitchen, without generator, at 88 dB-A. A single MBU in our burner test facility (small room, concrete walls) measured 80 dB-A and 88 dB-C at one meter.

The sound level in an MKT with M2 burners was 70 dB-A. The sound level in an MKT, with six MBUs and generator operating was 82 dB-A. The sound levels at cook locations in the CHUCK wagon (Table 3) were around 72 dB-A. There will be one more modification made to reduce CHUCK wagon sound levels; preliminary test results of these modifications demonstrate possible reduction by 2 dB-A in some parts of the cooking area and 10 dB-A adjacent to the mechanical area.

Table D-2 Summary of Sound Levels in MKT Configurations

Burners	Comments	Location	Height	Noise level	Time taken
				(dBA)	(hh:mm)
M2	4 burners & talking	Kitchen Center	56"	72	n/av
		Outside 6 ft from M59 corner	Chest	68	11:33
MBU	No burners - gen idle	Inside MKT-I	n/av	80	9:16
		1 mtr frm cold idling gen	n/av	83	9:16
	Gen, 4 burners lit/1 fueling	Center of MKT-I	54"	83	10:17
	Gen, 4 burners lit	Center of MKT-I	54"	83	10:19
	Gen, 4 burners lit	Inside MKT-I	n/av	84	n/av
	Gen, 6 burners lit	n/av	n/av	82	10:24

Values measured in dBC were converted to dBA equivalents

Sound level measurements for the CHUCK are found in **Table D-3** with the locations of measurement illustrated in **Figure D-1**.

Subjectively speaking, the sound of M2 burners is a moderate hiss, the sound of MBUs is a growling throb; and the sound of the CHUCK wagon is a low rumbling. During the test when the CHUCK sound measurements were taken, the cooks felt comfortable standing around the oven in quiet conversation during down periods.

D-2 Summary

A primary factor effecting personnel performance during operations in any kitchen is comfort, particularly with regard to environmental conditions such as air quality and sound levels.

It is widely accepted that the venting of burner combustion products in the vicinity of people, is unwise; despite complete ventilation there remains a danger of cooks directly inhaling fumes leaking around the edges of appliances. Results for air quality are not presented for this test, but since combustion gas entering the kitchen would be a direct contributor, exhaust from the burners used in each trailer was monitored. The CHUCK burner is more efficient at 65% than either of the MKT burner/appliance combinations (20%) and exhaust gases are vented outside of the cooking area as are other gaseous cooking products such as steam and airborne grease.

Sound levels in each of the kitchens were measured. In the MKT with M2 burners, the noise amounted to a 70 dB-A hiss. The MKT-I with MBUs was an 82 dB-A growl, and in the CHUCK Wagon it was a 72 dB-A rumble. Subjectively, perceived sound intensity followed the numbers measured.

**Table D-3 Sound Levels
in CHUCK Wagon**

Location*	Sound Level (dB-A)
1	75
2	74
3	74
4	74
5**	72
6	71
7	71
8	73
9	n/av
10	
11	
12	

*See Figure 1 for location illustration.

**Bold items are for cooking area.

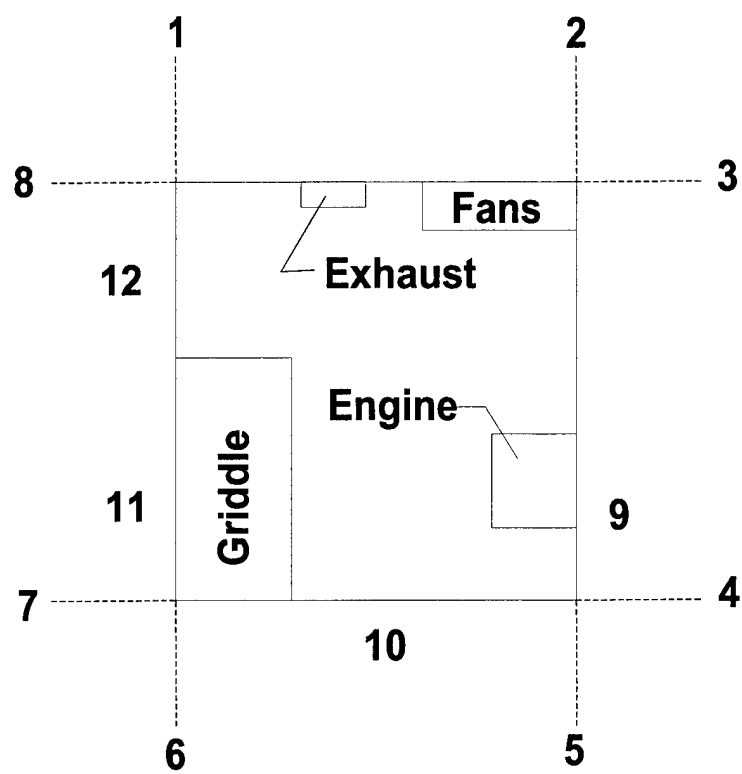


Figure D-1 Location of Sound Measurements around CHUCK Wagon

Appendix E - Weight and Inventory of the MKT and CHUCK Wagon Trailers

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Appendix E Weight and Inventory Analysis of the MKT and CHUCK Wagon Kitchens

E-1 Introduction

A study was performed to compare the transport weight of fully equipped Mobile Kitchen Trailers (MKTs) with the Centralized Heating Unit Cogeneration Kitchen (CHUCK Wagon). Two MKT configurations were evaluated: the standard MKT and the MKT, Improved (MKT-I). Once the trailers were fully stocked, they were lifted by fork truck onto high capacity scales. This report covers the results of these measurement and identifies the number of loose components required for each configuration.

E-1.1 MKT Description

The standard MKT consists of a shelter, appliances, cabinetry, burners and a plethora of cooking implements integrated with and loaded onto the military 1 ½ ton cargo trailer commonly known as an M105. The shelter consists of a fold out flooring system with stairs, a hard roof with vents, and flexible side walls of either screen or treated canvas material supported by aluminum poles. The removable but more or less permanently installed appliances and cabinetry include two ranges (M59s), one long work surface with storage space underneath, two cabinets, and a low storage space which spans beneath the griddle and cook rack assemblies. There are four burner racks which support a griddle and cook racks. There is also a movable insulated ice chest.

E-1.2 MKT-I Description

The MKT-I includes all of the above items, as well as some additional amenities. There is a circulation fan which pushes warm overhead air down to foot level, and the old gasoline lanterns have been upgraded to florescent lighting. The burners were upgraded from the gasoline fueled M2, to the Modern Burner Unit (MBU). These items require electrical power which will be supplied by a 2 kW generator transported aboard the towing vehicle (typically a 2 ½ or 5 ton truck). The MKT-I also comes with skirting around the trailer base, and floor matting.

E-1.3 CHUCK Wagon Description

The CHUCK Wagon is a smaller kitchen intended to feed the same number of soldiers but towable behind a HMMWV. Its florescent lighting, appliances, generator and heat producing equipment are all mounted permanently on a High Mobility Trailer (HMT). Loose items loaded inside include Cambros, utensils, tables and pots, and two aluminum struts used for roof support. A three piece flooring system is loaded on the rear of the trailer during transport. Shelter is provided by three fold-up awnings hinged at the roof-line, as well as a fold up curtain wall transported on the towing vehicle.

E-2 Inventory Development

The first step in determining transport weights was to clarify exactly what items are loaded onto each trailer. This was more complex than consulting a single manual. Although it's a stock item, determination of parts inventory for the MKT was difficult due to conflicting sources of information; several sources of military doctrine were consulted. The MKT-I is, in part, a developmental item so while some information was found in MKT manuals, other inventory information came from draft documentation. The CHUCK wagon is prototype equipment; an equipment list was generated in parallel with this study. The final MKT inventory as shown in **Section E-2.2** was comprised of parts lists from MKT and M59 documentation and consultations with our Military Field-Feeding Consultant (MFFC). Since MKT inventory can vary with mission or interpretation of doctrine, every attempt was made to provide a list malleable enough for anyone to easily draw off for future weight estimations as trailer configurations change. In general though, the weight will not change a great deal relative to the overall kitchen mass.

E-2.1 Information Sources and Doctrine Interpretation

References used for development of MKT inventory included technical manuals (TMs) and military specification documents (Mil-Specs) as follows:

Document ID#	Description
TM 10-7360-206-13	MKT Technical Manual through 1982
TM 10 -7360-206-23P	Supplement to MKT TM through 1995
TM-10-7360-204-13&P	M59 Range Cabinet Technical Manual through 1997
MIL-K-43911B	MKT Military Specification through 1997
MIL-C-40077E	M59 Range Cabinet Military Specification through 1985

The M59 documents have been inactivated because the range can now be purchased with a single National Stock Number (NSN). Although the MKT TM is supposedly only valid through 1982 it does contain info on the MKT-95.

The MKT TM, our primary source of information, is fairly complete, yet, it broadly refers to inclusion of two M59 range cabinets kits, these in turn including their own M2 burner assemblies. Both the M59 and M2 have manuals containing inventory information, but difficulties arise in that some parts included with the M2 burner duplicate those called for in the M59 kit, and some of the M59 kit parts duplicate those called for in the MKT manual. Although it might seem Mil-Specs for these would contain explicit instruction on each of the diminutive parts comprising single kits, without reliance on circular references, in general they shed no additional light on actual inventory requirements. The Mil-Spec for the MKT was identical to the TM in that it also identified only whole M59 kits rather than individual parts. And MIL-B-40098H, the spec for the M2 burner, for instance, did not specify spare generators and the removable pre-heater shield as separate parts of the unit although they are always included as spares attached to the chassis. Such detail is not included in specs because many parts in the

inventories of the MKT, M59's and burners are not to be supplied by the vendor of the kitchen but instead as Government Furnished Equipment (GFE). Furthermore, the term assembly is often vague; it may refer to parts which are attached, parts not attached but used together, or a single part such as the grill constructed by welding pieces together.

Table E-1 highlights the results of summing TM inventories. In general, where each manual calls for an item, it is interpreted that the sum equals the total required for a complete kitchen inventory.

Then, most items called for by the M59 manual, besides the accessory kit, are multiplied by two reflecting the fact there are two range cabinets aboard an MKT. The total number of burners, for instance, is calculated by noting that with one burner is required for each range cabinet; these combined with the four called for by the MKT manual, total six, be they M2s or MBUs.

Table E-1 Summary of Overlapping MKT, M59, and M2 Inventories towards the Assembly of a Complete MKT Kit

Item Description	Source	Source Count	Sum Total	Assumed Total	Notes
Accessory Outfit, Field Range	TM (1)	1	2	1	But, having two of the pumps included in the kit might be useful to speed up the lighting process.
	TM (2)	1			
Burner Units	TM (1)	4	6	6	MFFC concurred on this
	TM (2)	2			
Fire Extinguisher	TM (1)	2	4	4	Two onboard the MKT and one at each burner station seems reasonable.
	TM (2)	2			
Gasoline can spout	TM (1)	1	2	2	Having two might be useful to speed up the lighting process.
	TM (2)	1			
Generator	TM (2)	1	13	13	Each M2 already comes with two generators, but it may be wise to have an additional spare kickin' around.
	See Note	12			
Shield Assembly	TM (2)	1	7	7	While each burner comes equipped with a shield, a spare may be useful for expediting cold weather starts.
	See Note	6			
Can Opener, Mounted	TM (1)	1	2	2	Since the one on the MKT does not come with a movable mount it may be useful to install a portable one on any tables used outside.
	TM (2)	1			
TrayPack warmer adapter	TM (1)	2	4	2	Since don't have four squareheads, can't use all four.
	TM (2)	2			
Ladle	TM (1)	1	5	5	
	TM (2)	4			
Spoon, Regular	TM (1)	1	5	5	MFFC concurred on this
	TM (2)	4			
Spoon, Straining	TM (1)	2	4	4	
	TM (2)	2			
Fork	TM (1)	2	6	6	
	TM (2)	4			

Items in shaded cells indicate that the number is different than that interpreted from the technical manual.

TM (1) 10-7360-206-13, MKT Technical Manual through 82
10-7360-206-23P, Supplement to MKT TM through 95

TM (2) TM-10-7360-204-13&P M59 Technical Manual through 83

A notable exception to this ruling is the range accessory kit which amounts to a tool box and assorted other components. The M59 range cabinet TM calls for one accessory kit to be supplied for every 1 to 4 ranges being used. Although the MKT manual also calls for one accessory kit, it is assumed that only one, and not two, are needed.

An accessory kit includes two fire extinguishers. The MKT inventory also calls for two extinguishers bringing the total to four. This total seems prudent, but may be a little too conservative given the incendiary nature of M2 burners. The FM 10-23, Basic Doctrine for Army Field-Feeding and Class I Operations Management calls for one extinguisher at each of the lighting, filling and fuel storage stations leaving only one aboard the kitchen. It may be wise to consider that two more could be used, at least in scenarios including the M2 burner.

In the case of traypack-to-squarehead adapters, two range cabinets would require two adapters. The MKT manual requires two more, and yet, since there are only two squareheads aboard, it is assumed that a total of only two could be used at once.

A complete inventory of the M59 range cabinet and accompanying accessory kit can be seen in **Table E-2** as support for data in **Table E-1**. Some individual item weights are include to assist the reader in customizing their own total kitchen weight estimates.

E-2.2 Complete MKT and CHUCK Inventories

Tables 3 through 6 show the final inventory result broken into specific categories. They were compiled using information from the MKT TM, the M59 kit inventory and include other undocumented items in common field use as suggested by the MFFC. In certain situations, additional equipment such as burners, fuel, fire extinguishers or kitchen implements may be desired. These tables highlight items which are duplicated between the manuals (indicated by an asterisk) and include information on individual part weights. They show the quantity of each item used in the study and calculate a total weight contribution for the sum. When a total of any item is shown, this is the assumed total based on criteria already discussed. Some items are listed which are not called for in a the TM, such as the burner racks. They are considered a standard permanent part of the MKT even though they are moved more during operation than the condiment cabinet which is a component listed in the TM as part of trailer inventory. The tables also include items which would only be included as part of an MKT-I.

Table E-3 begins with an inventory of all the tools required for setup, maintenance and cleaning of the shelter, and operation and repair of the burners. Major items included beside the accessory kit, the roof lifting jacks, the stabilizer jack handles and a broom. Also included are a fuel can spout and funnel. The full tool box used in the study was 29 lbs; because an accurate box inventory was not possible, actual field weights may differ. Ordinarily the pump would be in the tool box but we used a foot pump which, at 7.8 lbs, was heavier and larger than the standard issue. Although only one pump was used in the study, it is thought that two may be useful to speed the lighting process. The pumps would not be needed at all when the MBU's are used.

Table E-2 Comprehensive Parts List for M59 Range

Category	Item		Quantity		Weight of One (1)
	Description	Comments	Called for in TM	Used for two kits	
Accessory Outfit (Use one outfit for 1-4 ranges)	Tool Box		1	1	n/av
	Box Wrench, 3/4	For M2 drain plug	1	1	n/av
	Adjustable Crescent Wrench		1	1	n/av
	7/16 Nut Driver	Only used with MBU	1	1	n/av
	Screwdrivers flat		2	2	n/av
	Sharpening stone		1	1	n/av
	Pump, M2 Inflating		1	1	7.8
	Lubricating oil		1	1	n/av
	Anti-seize compound		1	1	n/av
	Wire Brush		1	1	n/av
	Brush, Cleaning	Only used with MBU	1	1	n/av
	Cleaner, Burner, Slot		1	1	n/av
	Protector, Arm, Gasoline	or gloves	2	2	n/av
	Wrench, Assembly		1	1	n/av
	Screwdriver, Philips head		1	1	n/av
	Fire extinguishers		2	2	n/av
	Generator, Preheater		1	1	n/av
	Generator Assembly		1	1	n/av
	Shield Assembly, Preheater		1	1	n/av
	Can spout		1	1	n/av
	Opener, can (large, w clamp)		1	1	n/av
Pots and Such	Pan, Rectangular	Small Sheet Pan	2	4	96
	Pan, Baking and Roasting, Deep	Squarehead	1	2	
	Cover, Baking and Roasting Pan		1	2	
	Pot, Cooking, 15 gal		1	2	
	Cover, Cook Pot 15 gal		1	2	18.7
	Pot, Cooking, 10 gal		1	2	
	Cover, Cook Pot 15 gal		1	2	
	Cook pot cradle		1	2	11
	Traypack Warmer Adapter		1	2	n/av
	Insulated Container Insert Adapter	Either Mrmt or Cambr	1	2	7
Utensils	Dipper, Kitchen		2	4	n/av
	Ladle, Kitchen		1	2	n/av
	Ladle		1	2	n/av
	Kitchen, Skimmer		1	2	n/av
	Turner, Food		1	2	n/av
	Peeler, Potato, Hand		2	4	n/av
	Measuring Set, Spoon		2	4	n/av
	Knife, Paring		2	4	n/av
	Knife, Boning		2	4	n/av
	Knife, Cooks		2	4	n/av
	Spoon, basting		2	4	n/av
	Fork, Food Preparation		2	4	n/av
	Butcher's Steel		1	2	n/av
	Baker's Scraper		1	2	n/av
	Spoon, Food Service (straining)		1	2	n/av
	Whip, egg		1	2	n/av
Misc.	Burner Unit	M2 (or...)	1	2	45
		MBU	1	2	38
	Rack, Middle		1	2	n/av
	Rack, Bottom		1	2	n/av
	Rack, Top		1	2	1.75

Table E-3 MKT Tools Inventory

Category	Item			Quantity			Weight of (1)	Total Weight Contribution
	Description	Source	Comments	Called for by Source	Total Called For	Used in Study		
Tools	Accessory Outfit, Field Range* (an inventory of the outfit follows)	TM (1)	M59 Tool Box w/tools	1	1	1	29**	29**
		TM (2)		1				
	A field range accessory outfit consists of:							
	Tool Box	TM (2)		1	1	1	n/av	n/av
	Box Wrench, 3/4	TM (2)	For M2 drain plug	1	1	1	n/av	n/av
	Adjustable Wrench	TM (2)		1	1	1	n/av	n/av
	7/16 Nut Driver	TM (2)	Only with MBU	1	1	1	n/av	n/av
	Screwdriver, flat	TM (2)		2	2	2	n/av	n/av
	Sharpening stone	TM (2)		1	1	1	n/av	n/av
	Pump, M2 Inflating*	TM (2)	Not used with MBU	1	1	1	n/av	n/av
	Lubricating oil	TM (2)		1	1	1	n/av	n/av
	Anti-seize compound	TM (2)		1	1	1	n/av	n/av
	Wire Brush	TM (2)		1	1	1	n/av	n/av
	Brush, Cleaning	TM (2)		1	1	1	n/av	n/av
	Cleaner, Burner, Slot	TM (2)	Only with MBU	1	1	***	n/av	n/av
	Protector, Arm, Gasoline	TM (2)		2	2	2	n/av	n/av
	Wrench, Assembly	TM (2)		1	1	***	n/av	n/av
	Screwdriver, Philips head	TM (2)		1	1	1	n/av	n/av
	Handle, Jack	TM (1)	Used on stabilizers	4	4	4	2.13	8.52
	Funnel Assy	MFFC	For emptying burners	1	1	1	n/av	n/av
	Jack, Roof Lifting	TM (1)	For setup with 2 people	2	2	2	19.5	39
	Spout, Can, Fuel*	TM (1)		1	2	0	n/av	n/av
		TM (2)		1				
	Broom	MFFC		1	1	0	n/av	n/av

TM (1) = 10-7360-206-13, MKT manual thru 82
& 10-7360-206-23P, Supplement thru 95

TM (2) = TM-10-7360-204-13&P M59 manual thru 83

MFFC indicates the Military Field Feeding Consultant

* indicates items duplicated between manuals

** indicates that not all tools were found and so this weight may only be representative of an actual kit

*** Indicates items which were not inventoried carefully but would be comprehensively included in the tool box

Table E-4 goes on to list all appliances and large kitchen equipment. This includes pots and pans, the ranges, storage cabinets, burner units, ice chest, tables and fuel, and water and food containers. Although the MKT manual calls for inclusion of water sterilization bags, none of the MFFCs has ever seen one, and we have never seen any during field-feeding exercises. The list does not show the work surface cabinetry or the storage cabinet beneath the griddle and cook rack assembly. Although these items are no less permanent than the condiment cabinet, they are not indicated in manuals as part of the inventory. Determination had to be made on the number

of food containers. Sources identified the number as low as 8 and as high as 16. The strongest evidence was for 14. The pack-out plan does not show where the tables are placed.

Table E-5 describes all cooking implements required, from the utensils, potato peelers and egg whips, to the chopping board, colander and knife holster. Although not specified in the manual, our MFFC advised us that hot pads are commonly included. The listing in **Table E-5** is slightly different than in the other tables in that with the many duplicated items present, we preferred to group them by manual. Also, one of the large can openers is actually part of the M59 accessory kit and therefore it is assumed only one, and not three, is required. It could be interpreted that this can opener is not needed and duplicates the one on the MKT, but it is thought that since its clamping mechanism is transferable to outside tables, it could be useful.

Finally, **Table E-6** shows parts for the trailer and shelter. This includes fabric, poles and lights. It also places some items such as the rain trough, fire extinguishers and transport straps into a miscellaneous category. The material used for the shelter was TEMPER and would weigh more contrary to belief, than the cotton canvas the kitchen commonly contains. This weight difference, and others, will be addressed in **Table E-7** in which all missing, duplicate or substitution parts are listed to demonstrate how the weight of the test trailer should be adjusted for accuracy.

Table E-8 contains the inventory for all loose components of the CHUCK wagon. Only one item, the shelter side wall, is intended to be transported aboard the towing vehicle at this time. The inventory packed aboard the trailer can be seen in **Figure E-1** and **Figure E-2**.

E-2.3 Inventory Comparison

By summing all items listed in Tables 3 through 6 the total number of parts in the MKT-I inventory was found to be just over 270. This did not including diminutive items either in the tool chest or attached to the burners; the tool box was considered to be one item and each burner as one item. In some cases when counting pieces in the MKT inventory, there were some items which were identified as single, yet is actually several pieces. One such item was the floor matting which is actually five pieces. The CHUCK wagon inventory comprises 90 parts. When the two inventories were compared, some 15 additional items were identified for consideration of future inclusion with the CHUCK wagon. Naturally these items must somehow fit aboard the already full trailer or packaged in a box on the towing vehicle much the same as some MKT items. Even with the addition of these components, the MKT still requires over twice as many loose parts as the CHUCK wagon.

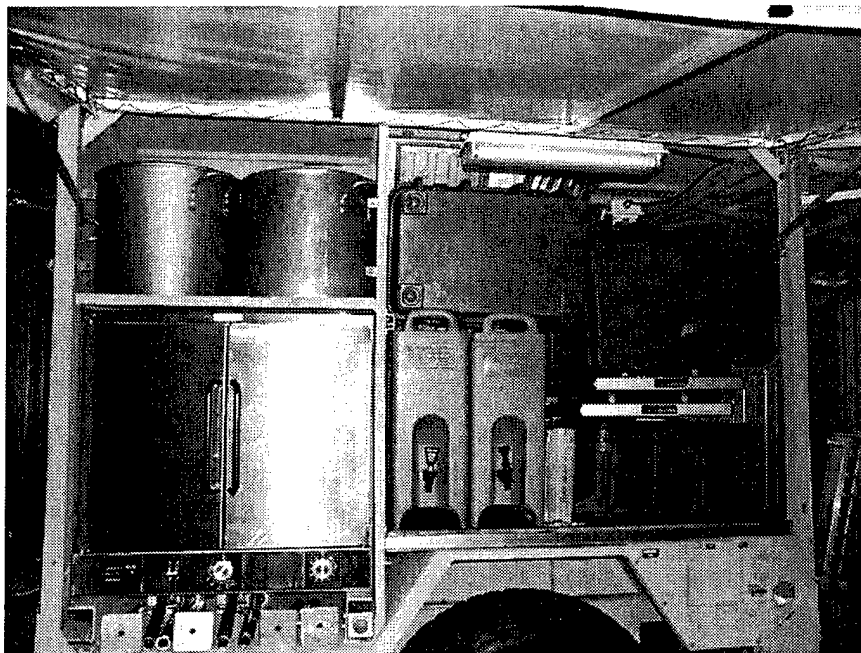


Figure E-1 Items Stored for Transit Over Oven and Griddle

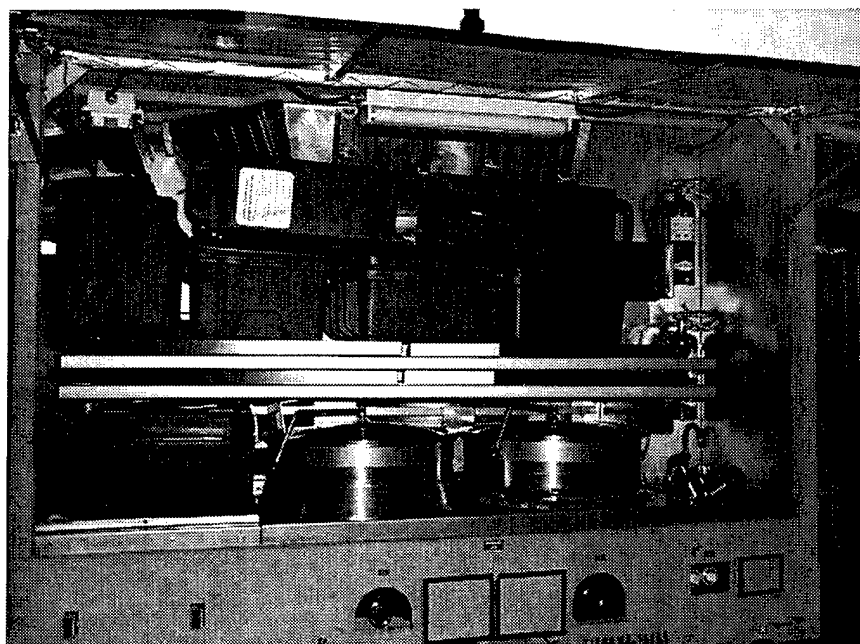


Figure E-2 Items Stored for Transport Kettles

Table E-4 Inventory of Appliances and Kitchen Equipment for MKT

Category	Item			Quantity			Weight of One (1)	Total Weight Contribution
	Description	Source	Comments	Called for by Source	Total Called For	Used in Study		
Appliances and Kitchen Equipment	Giddle Assy	TM (1)	one part, giddle top	1	1	1	65	65
	Grease Splash Guard Assy	TM (1)	three parts	1	1	1	15	15
	Catcher Assy., Grease and Funnel Assy	TM (1)	2 parts	1	1	1	2.4	2.4
	Range Outfit*	TM (1)	M59 cabinet with parts	2	2	2	n/av	n/av
	A range outfit includes:							
	Rack, Middle	TM (2)	For shielding and modulating heat throughout oven	1	2	0	n/av	n/av
	Rack, Bottom	TM (2)		2	4	0	n/av	n/av
	Rack, Top	TM (2)		1	2	0	1.75	0
	Cook pot cradle	TM (2)		1	2	1	11.1	11.1
	Insulated Container Insert Adapter	TM (2)		1	2	2	7.2	14.4
	Pan, Rectangular	TM (2)		2	4	2	3.1	6.2
	Pan, Baking and Roasting, Deep	TM (2)		1	2	2	16.3	32.6
	Cover, Baking and Roasting Pan	TM (2)		1	2	2	12.96	25.92
	Pot, Cooking, 15 gal	TM (2)		1	2	2	11.6	23.2
	Cover, Cook Pot 15 gal	TM (2)		1	2	2	n/av	n/av
	Pot, Cooking, 10 gal	TM (2)		1	2	2	n/av	n/av
	Cover, Cook Pot 10 gal	TM (2)		1	2	2	n/av	n/av
	Utensil Holder Assy	TM (1)	overhead corner bar	2	2	1	0.5	0.5
	Tray, Condiment	TM (1)		1	1	1	2.5	2.5
	Rack, Cutlery	TM (1)		1	1	1	5.9	5.9
	Cooking Rack Assy	TM (1)	1 part, also called grill	4	4	4	8.75	35
	Can, Fuel, 5-Gallon	TM (1)		3	3	0	40	0
	Can, Water, 5-Gallon	TM (1)	Plastic	8	8	6	5.17	31.02
			Metal			2	10	20
	Burner units*	TM (1)	M2	4	4	0	45	0
			MBU for MKT-I			4	38	152
		TM (2)	M2	2	2	0	45	0
			MBU for MKT-I			2	38	76
	An M2 burner unit will include:							
	Generator Assembly*	TM (2)		1	13	0	n/av	n/av
		w/M2	2 of these usuly w/M2	12				
	Sheild Assembly, Preheater*	TM (2)		1	7	0	0.6	0
		w/M2	1 prt usuly incld w/M2	6				
	MBU Power supply (if MBUs)	I	weighed with bracket	1	1	1	39	39
	Burner racks	TM (1)		4	4	4	n/av	n/av
	Generator, Preheater	TM (2)	not used with MBU	1	1	0	n/av	n/av
	Movable Cabinet Assy	TM (1)		1	1	1	78	78
	Condiment Cabinet	TM (1)		1	1	1		
	Ice Chest	I	plastic Cambro (or...)	1	1	1	67	67
		TM (1)	aluminum box unit			0	n/av	n/av
	Dispenser, Liquid, Insulated	TM (1)	Cambro	12	12	12	15.9	190.8
	Food Container, Insulated	TM (1)	new plastic Cambro	12	12	12	15	180
	Table, Field	TM (1)	30x72 Alumalite 4' long	2	2	2	33	66
	Water Sterilization bags	TM (1)	MFEC says never used	2	2	0	n/av	n/av

TM (1) = 10-7360-206-13, MKT manual through 82
& 10-7360-206-23P, Supplement thru 95

TM (2) = TM-10-7360-204-13&P M59 manual thru 83

I indicates improvements for the MKT-I

* indicates items duplicated between manuals

Table E-5 Inventory of Cooking Implements for MKT

Category	Item			Quantity			Weight of One (1)*	Total Weight Contribution
	Description	Source	Comments	Called for by Source	Total Called For	Used in Study		
Cooking Implements**	<i>To be included as inventory of MKT, not range:</i>							
	Adapter, Traypack-to-squarehead*	TM (1)		2	2	*	2.5	*
	Hand can openers	TM (1)		8	8	0	n/av	n/av
	Mounted can opener w/o clamp	TM (1)	clamp perm on cab	1	1	1	n/av	n/av
	Board, Food slicing and chopping	TM (1)		1	1	1	n/av	n/av
	Colander, SS, 16-Quart	TM (1)		1	1	1	n/av	n/av
	Fork, 15 inch*	TM (1)		1	1	*	n/av	n/av
	Fork, 21 Inch*	TM (1)		1	1	*	n/av	n/av
	Ladle*	TM (1)		1	1	*	n/av	n/av
	T-pack lifter, regular	TM (1)		2	2	2	n/av	n/av
	T-pack lifter, serving	TM (1)		2	2	2	n/av	n/av
	Spoon, 15 inch*	TM (1)		1	1	*	n/av	n/av
	Spoon, Serving, Slotted, 15 inch*	TM (1)		2	2	*	n/av	n/av
	Tongs, Food Service, 12 inch	TM (1)		2	2	2	n/av	n/av
	12 in, Rolling, Wooden	TM (1)		1	1	1	n/av	n/av
	Knife Holder, Fabric	MFCC		1	1	1	n/av	n/av
	Hot pads	MFCC		4	4	3	n/av	n/av
	<i>A range outfit already includes:</i>							
	Adapter, Traypack-to-squarehead	TM (2)		2	4	1	2.5	2.5
	Dipper, Kitchen	TM (2)		4	4	4	n/av	n/av
	Mounted can opener w/clamp	TM (2)	Part of M59 Acc Kit	1	1	1	n/av	n/av
	Ladle, Kitchen*	TM (2)		2	*	*	n/av	n/av
	Ladle*	TM (2)		2	5	5	n/av	n/av
	Kitchen, Skimmer	TM (2)		2	2	2	n/av	n/av
	Turner, Food	TM (2)		2	2	2	n/av	n/av
	Peeler, Potato, Hand	TM (2)		4	4	4	n/av	n/av
	Measuring Set, Spoon	TM (2)		4	4	0	n/av	n/av
	Knife, Paring	TM (2)		4	4	0	n/av	n/av
	Knife, Boning	TM (2)		4	4	0	n/av	n/av
	Knife, Cooks	TM (2)		4	4	2	n/av	n/av
	Spoon, basting*	TM (2)		4	*	*	n/av	n/av
	Fork, Food Preparation*	TM (2)		4	6	6	n/av	n/av
	Butcher's Steel	TM (2)		2	2	1	n/av	n/av
	Baker's Scraper	TM (2)		2	2	0	n/av	n/av
	Spoon, Serving, Slotted, 15 inch	TM (2)		2	9	9	n/av	n/av
	Whip, egg	TM (2)		2	2	2	n/av	n/av

TM (1) = 10-7360-206-13, MKT manual thru 82
& 10-7360-206-23P, Supplement thru 95

TM (2) = TM-10-7360-204-13&P M59 manual thru 83

MFCC indicates the Military Field Feeding Consultant

I indicates improvements for the MKT-I

* indicates items duplicated between manuals
This symbol in quantity block indicates that the total will be shown below. Some items that are similar like 12 inch serving spoons and 15 inch regular spoons are totaled as the same item to keep things simple

Table E-6 Inventory of Shelter Parts for MKT

Category	Item			Quantity			Weight of 1 (item or set)	Total Weight Contribution
	Description	Source	Comments	Called for by Source	Total Called For	Used in Study		
Trailer/ Shelter	Fabric	TM (1)	TEMPER material	2	2	2	62	62
				2	2	2		
				2	2	2		
		TM (1)		2	2	2	44	44
				2	2	2		
				2	2	2		
		TM (1)	Integral with roof	1	1	1	n/av	n/av
				1	1	1	n/av	n/av
				1	1	1	n/av	n/av
				1	1	1	n/av	n/av
				2	2	2	n/av	n/av
		I		1	1	1	31	31
				1	1	1		
	Repair Kit, Fabric	TM (1)		1	1	0	n/av	n/av
	Poles	TM (1)		10	10	10	1.85	38.85
		TM (1)		4	4	4	n/av	n/av
		TM (1)	Incls shrt hngd pc.	12	12	12	4.13	86.73
		TM (1)	perm attchd corner	4	4	4	n/av	n/av
	Misc.	I	flouresent light (or...)	2	2	1	17	17
			gasoline lantern	3	3	0	5	0
		TM (1)	five pieces	1	1	1	224	224
		TM (1)	4 step stairs	3	3	3	44	132
		TM (1)	Banisters	6	6	6	4	24
		I	w/baseboard and duct	1	1	1	30	30
		TM (1)		2	4	3	15	45
		TM (2)		2				
		TM (1)		1	1	0	n/av	n/av
		TM (1)		2	2	0	n/av	n/av
		I	One like RDK's	1	1	1	4	4
		TM (1)	Used for packing	1	1	1	4	4
				2	2	0	4	0
				1	1	0	4	0
		I		1	1	1	1.5	1.5
		I		1	1	0	n/av	n/av
		I	aboard towing vehicle	1	1	0	140	140
		TM (1)		1	1	1	n/av	n/av

TM (1) 10-7360-206-13, MKT manual thru 82
10-7360-206-23P, Supplement thru 95

TM (2) TM-10-7360-204-13&P M59 manual thru

I indicates improvements for the MKT-I

* indicates items duplicated in manuals

Table E-7 Major Items Effecting Weight

Category	Item		Quantity Required	Unit weight	Weight as used	Potential diff	
	Description	Comments					
Need Adjustment	Tool Box	Depends on inventory	1	29*	29*	+/- 5	
	Tables	Depends on type	2	33	66	-20	
	Insulated Containers	Depends on inserts	12	15.9	191	+/- 20	
	broom	Depends on type	1	5	5*	+5	
	Water Jugs	Probably should be	8	6.2	51	-10	
Missing	hold down straps		3	4	12	+12	
	rain trough		1	10	10*	+10	
	technical manual		2	1	2*	+2	
	fuel cans		3	6	18	+18	
	repair kit		1	3	3*	+3	
	fire extinguishers	Could need even more	1	15	15	+15	
	water sterilization bags	Probably will never use	1	20	0	0	
	missing foot		1	15	0	+15	
Category Adjustment						+90	
MKT vs MKT-I	pump	For M2 drain plug	1	7.8	7.8	-3	-7.8
	griddle		1	65	65	-10	0
	burners		6	228	228	+52	0
	burner wiring		1	20	20	-20	0
	skirting		1	31	31	-31	0
	floor matting		1	224	224	-200	0
	lights (only used one light)	sans cover or bulbs	2	17	17	-2	+17
	power supply		1	39	39	-39	0
	fan and plenum		1	30	30	-30	0
	ice chest	Alum no longer avail	1	65	65	0	0
	tent material		1	181	181	+48	0
	ground rod		1	4	4	-4	0
	extension cord		1	10	0	0	+10
Category Adjustment						-239	+19
Total Adjustment						-149	+109

* indicates an estimate was made

To identify where most of the excess components arise from, we broke the inventory down into six categories. The breakdown is shown in **Table E-9**. The first category “Originally Loose”, contains items (such as appliances) that were originally movable and that required manipulation at any point in the meal, but, are now permanently integrated into the CHUCK wagon.

Integration saved 27 parts, the most significant of which are the burners, burner racks and the generator. The second category “Quantity Differences”, contains items included with both kits, but differing quantities. This category saved 62 pieces, mostly in terms of cooking implements. The third category “No Longer Required”, contains parts that are just no longer needed with the new kitchen. 60 parts were saved by use of the CHUCK wagon. The fourth category “Likely Required but Missing” identifies parts that were not used in the initial inventory but were later identified as possibly necessary. As stated in the previous paragraph, this comprised about 15 extra items. The fifth category “CHUCK Only”, identifies additional items required with the CHUCK wagon and amounts to about 25 extra pieces. The sixth and final category simply shows inventory items for which there is no change.

Table E-8 CHUCK Wagon Inventory

Item				Quantity			Weight of 1 (item or set)	Total Weight Contribution
Category	Description	Source	Comments	Called for by Source	Total Called For	Used in Study		
Cooking Implements	Utensils	Pot, 15 gallon with cover	*	2	2	2	n/av	44.84
		Pot, 10 gallon with cover	*	1	1	1		
		Fork, Type I	*	2	2	2		
		Turner, Type II	*	1	1	1		
		Scraper, Bakers	*	1	1	1		
		Measuring set (Spoons)	*	2	2	2		
		Spoon, Stainer	*	1	1	1		
		Skimmer	*	1	1	1		
		Knife, Cooks, Type IV	*	2	2	2		
		Knife, Boning	*	2	2	2		
		Whip, Egg	*	1	1	1		
		Knife, Paring	*	2	2	2		
		Ladle, Size 2	*	1	1	1		
		Ladle, Size 3	*	1	1	1		
		Butcher Steel, Type X	*	1	1	1		
		Peelers, Potato, Hand	*	2	2	2		
		Spoon, Basting	*	2	2	2		
		Tongs, Serving	*	4	4	4		
		Dipper, Type II, Size I	*	2	2	2		
	Containers/ Miscellaneous	Cambro Beverage Container	*	5	5	5	15	75
		Cambro with full size tray	*	5	5	5	18.75	93.75
		Sheet Tray	*	5	5	5	3	15
		Oven racks	*	5	5	5	5.33	26.65
		Mixing Paddle	*	1	1	1	2	2
		Cutting Board	*	1	1	1	10.46	10.46
		Can Opener and bracket	*	1	1	1	6.82	6.82
		Roasting Pan	*	2	2	2	5	10
		Mixing Bowls, Set	*	1	1	1	2	2
Trailer Parts	Miscellaneous	Tables	*	1	1	1	25.8	25.8
			*	1	1	1	23.25	23.25
		Fire Extinguishers	*	2	2	2	9.54	19.08
		Griddle wrist rail	*	1	1	1	3.04	3.04
		5 gallon fuel can (full)	*	2	2	2	42	84
		Kettle valves	*	2	2	2	5.32	10.64
		Trailer Jack	*	2	2	2	25.24	50.48
		Grounding cable	*	1	1	0	6.8	0
		Grounding rod	*	1	1	0	4	0
		Shore power cable	*	1	1	0	25.7	0
		Storage box	*	1	1	0	n/ap	0
		tongue Dolly	*	1	1	1	49.8	49.8
	Shelter/ Flooring	Roof Support truss	*	2	2	2	7.6	15.2
		Side wall	*	2	2	0	37.76	0
		Floor Transport Bracket	*	1	1	1	11.2	11.2
		Platform Leg	*	8	8	8	1.6	12.8
		Large Platform	*	1	1	1	77.8	77.8
		Small Platform	*	1	1	1	70.33	70.33
		Platform Bridge	*	1	1	1	28.4	28.4

* CHUCK inventory devised based on space limitations and interviews with personnel

Table E-9 MKT/CHUCK Differences

Category	Item Description	MKT	CHUCK	Addn'l MKT
Originally Loose	Griddle/Splash/Drain Assy	6	0	6
	Cook pot cradle	2		2
	Burner units	6		6
	Burner racks	4		4
	Lights	2		2
	2 kW Electrical Generator	1		1
	Cooking Rack Assy	4		4
	Utensil Holder Assy	2		2
Quantity differences	Oven Racks	8	5	3
	Pan, Rectangular	4	5	-1
	Pot, Cooking, 10 gal	2	1	1
	Cover, Cook Pot 10 gal	2	1	1
	Can, Fuel, 5-Gallon	3	2	1
	Dispenser, Liquid, Insulated	12	5	7
	Food Container, Insulated	12	5	7
	Fork, Food Preparation*	6	2	4
	Turner, Food	2	1	1
	Baker's Scraper	2	1	1
	Measuring Set, Spoon	4	2	2
	Spoons	9	3	6
	Kitchen, Skimmer	2	1	1
	Knives	14	7	7
	Whip, egg	2	1	1
	Ladle	5	2	3
	Peeler, Potato, Hand	4	2	2
	Tongs, Food Service, 12 inch	2	4	-2
	Dipper, Kitchen	4	2	2
	Mounted can opener	2	1	1
	Shelter fabric sections	12	1	11
	Skirting, left and rear	2	1	1
	Extinguisher, Fire	4	2	2
No Longer Required	Handle, Jack	4	0	4
	Jack, Roof Lifting	2		2
	Pan, Roasting, Sqrd	2		2
	Cover, Roasting Pan	2		2
	Water Sterilization bags	2		2
	Strap Assy, Aisle	5		5
	Receptical Pigtail	1		1
	Ladder Assy	9		9
	Fan and Heater Assy	1		1
	Rain Trough	1		1
	Hand Rail	10		10
	Ramp Corner Strut Assy	4		4
	Tent Pole Assy	12		12
	Strut Fabric Holdout Assy	4		4
	Hand crank, skylight	1		1

Table 9 (cont.)

Category	Item Description	MKT	CHUCK	Addn'l MKT
Likely Required but Missing	Tool Kit	1	1	0
	Funnel Assy	1	1	0
	Spout, Can, Fuel*	2	2	0
	Broom	1	1	0
	Insulated Cntnr Insert Adptr	2	2	0
	Tray, Condiment	1	0	1
	Rack, Cutlery	1	1	0
	Can, Water, 5-Gallon	8	4	4
	Ice Chest	1	1	0
	Colander, SS, 16-Quart	1	1	0
	T-pack lifter, regular	2	2	0
	T-pack lifter, serving	2	2	0
	12 in, Rolling, Wooden	1	1	0
	Knife Holder, Fabric	1	1	0
	Hot pads	4	4	0
	Adapter, Traypack-to-sqrhd	4	4	0
	Hand can openers	8	2	6
	Repair Kit, Fabric	1	1	0
	Technical Manual	2	2	0
	Rod, Ground	1	1	-1
	Matting, Floor	5	2	3
CHUCK Only	Mixing Paddle	0	1	-1
	Mixing Bowls, Set		1	-1
	Griddle wrist rail		1	-1
	Pan, Roasting		1	-1
	Kettle valves		2	-2
	Trailer Jack		2	-2
	Grounding cable		1	-1
	Shore power cable		1	-1
	tongue Dolly		1	-1
	Storage Box		1	-1
	Roof Support truss		2	-2
	Floor Transport Bracket		1	-1
	Platform Leg		8	-8
	Large Platform		1	-1
	Small Platform		1	-1
	Platform Bridge		1	-1
No Change	Pot, Cooking, 15 gal	2	2	0
	Cover, Cook Pot 15 gal	2	2	
	Table, Field	2	2	
	Board, Chopping	1	1	
	Roof Canopy Assy	2	2	
	Extension Cord	1	1	

E-3 Calculation of Total Trailer Weights

As complete an inventory as possible of the above parts was collected, and the trailer packed up for weighing. Certain considerations of inventory completeness, accuracy or variability are as detailed in **Table E-7** and broken into three categories; items which were missing, items on which there was some question of weight and items which differed between the MKT and MKT-I. Major missing items included the rain trough, fire extinguishers, water sterilization bags and one stabilizer foot. Items of questionable weight included the tool box, tables and insulated food containers.

Diminutive items (such as cooking implements or spare burner parts) in questionable quantity or type were omitted from this table for practical reasons. The one florescent light was weighed without the plastic cover or bulbs. There were no spare parts included for servicing the MBUs.

E-3.1 MKT Weight

A scale was placed under each tire and the tongue as illustrated in **Figure E-3**. This resulted in the values summarized by **Table E-10**. The gross weight of the trailer as it was configured for this study, was adjusted by -149 lbs to predict a weight of the MKT and +109 lbs to predict a weight of the MKT-I. The difference in weight predicted for the MKT with the weight taken from the MKT identification plate is only 4 lbs. The difference in weight between the MKT and MKT-I is 250 lbs. Engineers responsible for design of the MKT-I concurred with this value. It was beyond the scope of this project to estimate center of gravity for either MKT configuration so predicted values for independent tongue and tire weights are not listed.

The result precludes the possible existence of additional items such as food containers, food stored aboard the trailer, burners, pots, pans, tables or other cooking implements. It also assumes items such as a water hose and generator would be transported aboard the towing vehicle.

E-3.2 CHUCK Weight

Similarly the weight of the CHUCK wagon was measured as shown in **Figure E-4**. The values are summarized in **Table E-12**.

From the values in **Table E-12** we can calculate that the center of gravity is only 3 inches off a centerline along the length of the trailer toward the right tire. We can also calculate that the lengthwise center of gravity is 12.5 inches forward of the axle and that during transit, there will be 615 lbs resting on the pintle. The target weight of the fully loaded trailer was 4200 lbs with 420 lbs on the pintle. Overshoot was therefore 407 pounds and 195 pounds respectively.



Figure E-3 MKT Suspended Above Scales Prior To Weighing

Table E-10 Weight of MKT and MKT-I

	Measured	Predicted		Spec Plate	
	Mixed Inventory	MKT	MKT-I	MKT/Loaded	Trailer Only
Tongue	255	n/av	n/av	490	250
Left Tire	2854			5260	1410
Right Tire	2794				
Total	5903	5754	6012	5750	1660

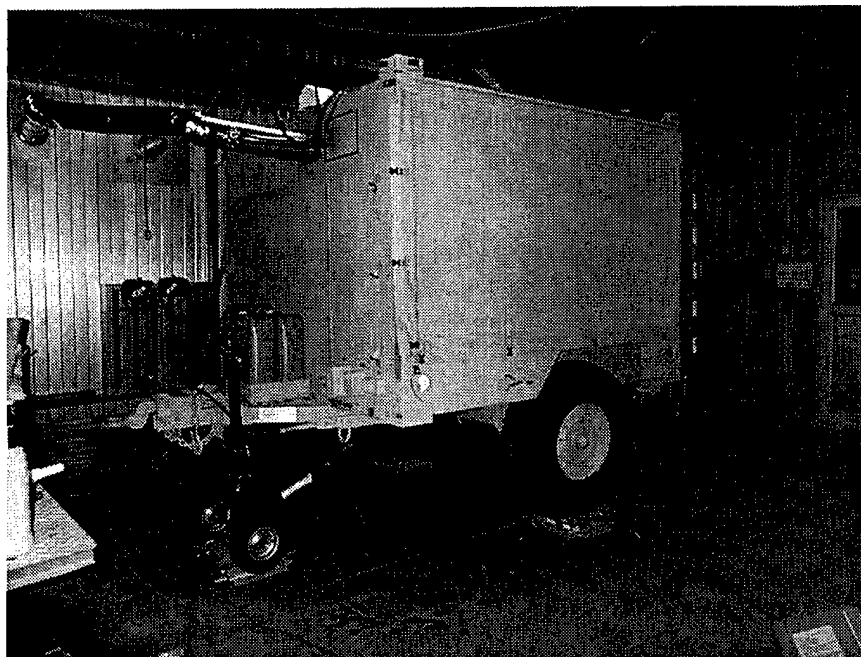


Figure E-4 CHUCK Wagon Resting on Scales

Table E-12 Weight of CHUCK Wagon

	Travel Configuration	Unpacked		
		w/o fuel	w/fuel	w/fuel+floor
Tongue	684	686	757	661
Left Tire	1845	1438	1436	1584
Right Tire	2078	1841	1857	1980
Total	4607	3966	4050	4225

**Table E-11 CHUCK
Wagon Dimensions**

Location	Dimension (inches)
Width-	
Trailer Center	0
CL of tire	36
Length-	
Tire	0
Floor Bracket	-38
Fuel	62
Pintle Jack	72
Pintle	94

E-4 Summary

The MKT, MKT-I and CHUCK Wagon kitchen trailers were outfitted with complete equipment inventories and then weighed to determine gross and tongue weight. The inventories were analyzed to assess number of parts and savings from one trailer to the next. MKT inventory was developed from military doctrine. The MKT-I is a developmental item and inventory information was gathered from military doctrine and draft documents. The CHUCK wagon is prototype equipment; the equipment list was generated in parallel with this study.

The weight difference between the MKT and the MKT-I was 250 pounds in favor of the standard MKT configuration. The weight difference between the MKT and the CHUCK Wagon was 1143 pounds in favor of the CHUCK wagon. Besides being lighter, the CHUCK Wagon is also towable by a smaller vehicle than the MKT.

Comparing the MKT-I and CHUCK parts inventories, we find the MKT-I has just over 270 parts and the CHUCK, 90. This savings is due to several factors inherent to the configuration of the CHUCK Wagon. These factors include the permanent attachment of some items onto the trailer itself, the integration of parts into the system, differences in quantity of some required loose items, and the elimination of items no longer required.

